IDS 10/715741

Y

First Hit Fwd Refs Previous Doc Next Doc Go to Doc#

Generate Collection Print

L6: Entry 1 of 2 File: USPT Apr 9, 2002

US-PAT-NO: 6370471
DOCUMENT-IDENTIFIER: US 6370471 B1
** See image for Certificate of Correction **

TITLE: Automatic following guidance system for motor vehicles

DATE-ISSUED: April 9, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Lohner; Herbert	Friolzheim			DE
Dominke; Peter	Bietigheim-Bissingen			DE
Cao; Chi-Thuan	Korntal-Muenchingen			DE
Leimbach; Klaus-Dieter	Moeglingen			DE
Harter; Werner	Illingen			DE
Hommel; Mathias	Wolfsburg			DE

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Robert Bosch GmbH				DE	03

APPL-NO: 09/ 719071 [PALM]
DATE FILED: January 8, 2001

FOREIGN-APPL-PRIORITY-DATA:

COUNTRY	APPL-NO	APPL-DATE
DE	199 16 095	April 9, 1999

PCT-DATA:

APPL-NO	DATE-FILED	PUB-NO	PUB-DATE	371-DATE	102(E)-DATE
PCT/DE00/01097	April 6, 2000	WO00/62139	Oct 19, 2000	Jan 8, 2001	Jan 8, 2001

INT-CL: [07] G06 F 165/00

US-CL-ISSUED: 701/96; 701/200, 701/36, 73/178R
US-CL-CURRENT: 701/96; 701/200, 701/36, 73/178R

FIELD-OF-SEARCH: 701/96, 701/23, 701/36, 701/200, 701/41, 701/93, 701/70, 701/178R

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
☐	4887223	December 1989	Christian	
☐	5179441	January 1993	Johnson et al.	
☐	5684696	November 1997	Rao et al.	701/25
☐	5925080	July 1999	Shimbara et al.	701/23
☐	5957983	September 1999	Tominaga	701/23
☐	5961559	October 1999	Shimbara et al.	701/23
☐	6115652	September 2000	Sato et al.	701/28
☐	6138062	October 2000	Usami	

ART-UNIT: 3661

PRIMARY-EXAMINER: Cuchlinski, Jr.; William A.

ASSISTANT-EXAMINER: Hernandez; Olga

ATTY-AGENT-FIRM: Baker & Daniels

ABSTRACT:

The invention concerns a system for automatic following guidance, particularly for heavy-traffic automatic following guidance, of a motor vehicle (1), designed to ease the burden on the driver in heavy-traffic situations both by taking over lateral guidance by means of an automatic steering regulation system and by maintaining a set distance from a leading vehicle. The latter function requires an adaptive cruise and braking regulation system with "stop" and "go" function. According to the invention, selection and decision means (5, 6, 7, 8, 9) are provided that select both the regulating parameters and the types of controllers [sic], e.g., following guidance of the motor vehicle (1) on the basis of lane markings recognized by means of a video camera or on the basis of a recognized leading vehicle. The system is divided into hierarchical levels I-IV, the driver always being in the monitoring and adaptation loop assigned to the top level IV of the hierarchy, so that he has the highest priority and can override the system at any time.

17 Claims, 2 Drawing figures

Previous Doc Next Doc Go to Doc#

IDS 10/716741

US006370471B1

(12) **United States Patent**
Lohner et al.

(10) **Patent No.: US 6,370,471 B1**
(45) **Date of Patent: Apr. 9, 2002**

(54) **AUTOMATIC FOLLOWING GUIDANCE SYSTEM FOR MOTOR VEHICLES**

(75) Inventors: **Herbert Lohner**, Friolzheim; **Peter Dominke**, Bietigheim-Bissingen; **Chi-Thuan Cao**, Korntal-Muenchingen; **Klaus-Dieter Leimbach**, Moeglingen; **Werner Harter**, Illingen; **Mathias Hommel**, Wolfsburg, all of (DE)

(73) Assignee: **Robert Bosch GmbH** (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/719,071**

(22) PCT Filed: **Apr. 6, 2000**

(86) PCT No.: **PCT/DE00/01097**

§ 371 Date: **Jan. 8, 2001**

§ 102(e) Date: **Jan. 8, 2001**

(87) PCT Pub. No.: **WO00/62139**

PCT Pub. Date: **Oct. 19, 2000**

(30) **Foreign Application Priority Data**

Apr. 9, 1999 (DE) 199 16 095

(51) **Int. Cl.**^{7} **G06F 165/00**

(52) **U.S. Cl.** .... 701/96; 701/200; 701/36; 73/178 R

(58) **Field of Search** .... 701/96, 23, 36, 701/200, 41, 93, 70, 178 R

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,887,223 A		12/1989	Christian	
5,179,441 A		1/1993	Johnson et al.	
5,684,696 A	*	11/1997	Rao et al.	701/25
5,925,080 A	*	7/1999	Shimbara et al.	701/23
5,957,983 A	*	9/1999	Tominaga	701/23
5,961,559 A	*	10/1999	Shimbara et al.	701/23
6,115,652 A	*	9/2000	Sato et al.	701/28
6,138,062 A	*	10/2000	Usami	

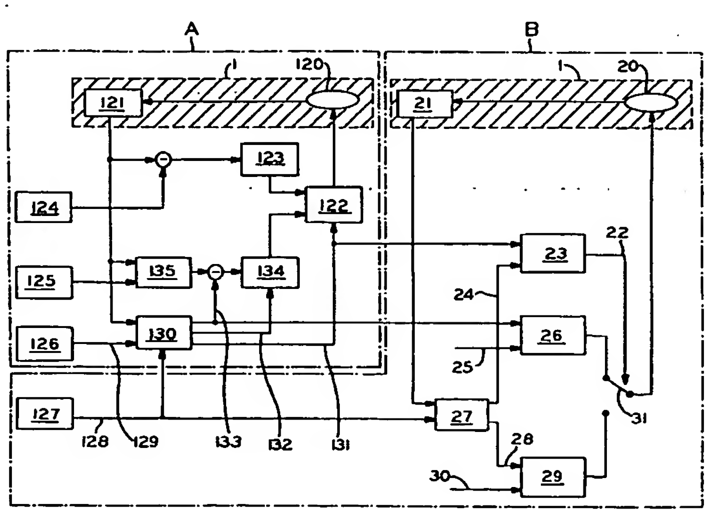
* cited by examiner

Primary Examiner—William A. Cuchlinski, Jr.
Assistant Examiner—Olga Hernandez
(74) *Attorney, Agent, or Firm*—Baker & Daniels

(57) **ABSTRACT**

The invention concerns a system for automatic following guidance, particularly for heavy-traffic automatic following guidance, of a motor vehicle (1), designed to ease the burden on the driver in heavy-traffic situations both by taking over lateral guidance by means of an automatic steering regulation system and by maintaining a set distance from a leading vehicle. The latter function requires an adaptive cruise and braking regulation system with "stop" and "go" function. According to the invention, selection and decision means (5, 6, 7, 8, 9) are provided that select both the regulating parameters and the types of controllers [sic], e.g., following guidance of the motor vehicle (1) on the basis of lane markings recognized by means of a video camera or on the basis of a recognized leading vehicle. The system is divided into hierarchical levels I–IV, the driver always being in the monitoring and adaptation loop assigned to the top level IV of the hierarchy, so that he has the highest priority and can override the system at any time.

17 Claims, 2 Drawing Sheets



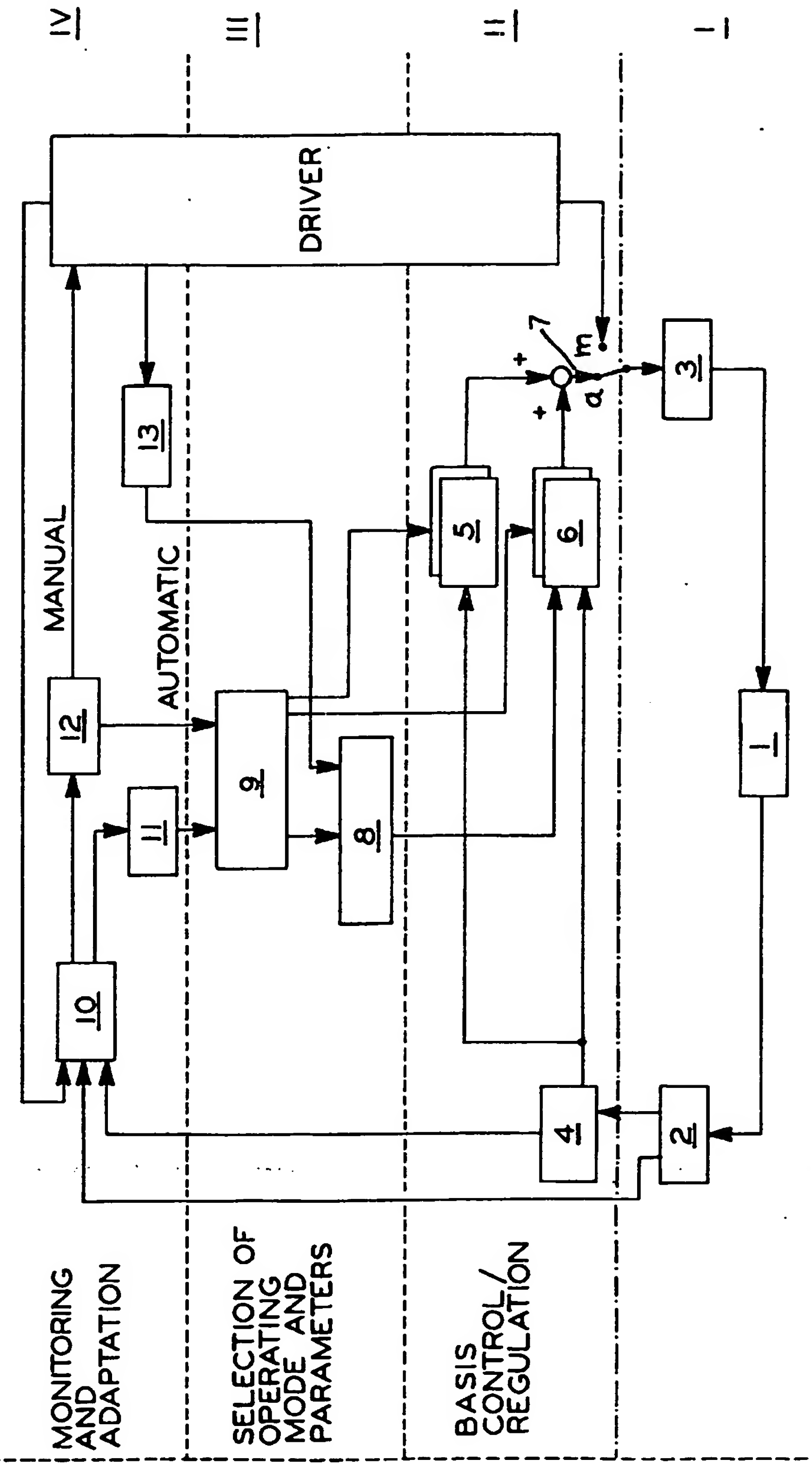

IV
III
II
I
DRIVER
MANUAL
AUTOMATIC
13
12
11
10
9
8
7
6
5
4
3
2
1
m
a
+
+
MONITORING AND ADAPTATION
SELECTION OF OPERATING MODE AND PARAMETERS
BASIS CONTROL/ REGULATION

FIG. 1

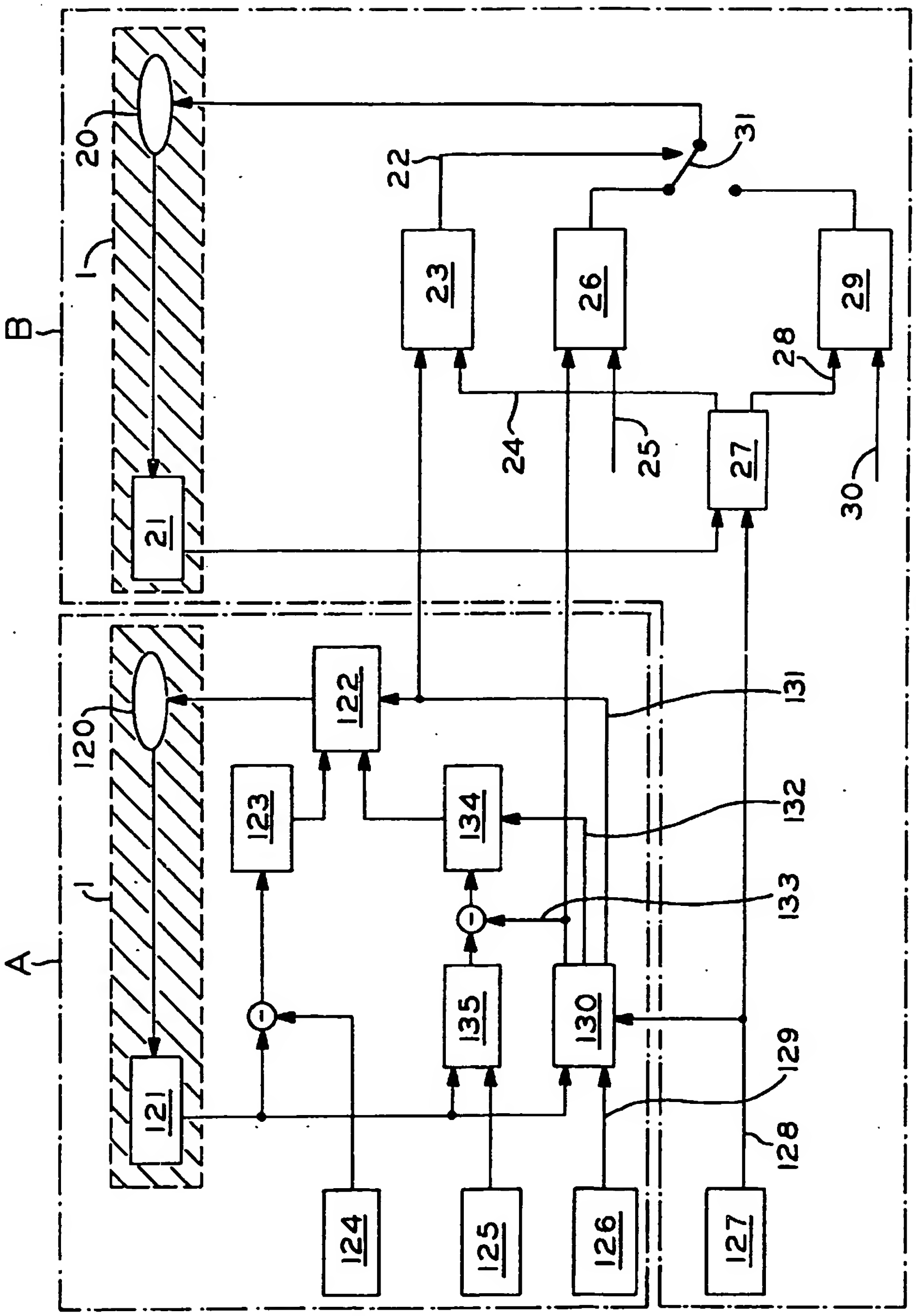


FIG. 2

AUTOMATIC FOLLOWING GUIDANCE SYSTEM FOR MOTOR VEHICLES

PRIOR ART

The invention concerns a system for automatic following guidance, particularly for heavy-traffic following guidance, of a motor vehicle, comprising

- an electronic cruise, braking and steering control/regulation system,
- an environmental image acquisition unit equipped with a video camera and downstream image analysis and generating signals that can be input to the electronic cruise, braking and steering control system at least for automatic guidance along a marked traffic lane, and/or
- an environmental detection unit operating on the basis of detected reflections of emitted electromagnetic radiation, and
- a spacing and relative-speed detection unit that detects a spacing and a relative speed with respect to a leading vehicle selectable on the basis of signals generated by the environmental image acquisition unit and generates in each case a corresponding spacing and relative speed detection signal.

A similar system is described in U.S. Pat. No. 5,684,697. In the known system, image frames supplied by the video camera are digitized and are processed by a computer, which automatically controls or regulates the steering, acceleration, deceleration and braking of the vehicle within specified criteria. The automatic steering of the vehicle is based on the acquisition of images of stripe-shaped road markings, whereas the automatic speed control or regulation is based on detecting the location of a leading vehicle within the marked traffic lane.

By contrast, a further system, known from U.S. Pat. No. 5,572,449, employs speed signals that are detected both by a vehicle to be controlled and by a preceding, leading vehicle and are exchanged via a communication system in order to determine the relative speed between the two vehicles and to generate control signals that stabilize the speed and thus a safe following distance of the trailing vehicle with respect to the leading vehicle, and further, to control the steering in such a way that the trailing vehicle can follow the preceding one. A disadvantage here is that all vehicles traveling in a column must be equipped with the same system.

A further system, known from U.S. Pat. No. 5,245,422, like U.S. Pat. No. 5,684,697, employs a video camera and its images, processed by an image processor, to define the lane markings on the road and the position of the vehicle with respect thereto. The combined engagement of a cruise control switch and a steering control switch are [sic] detected and used to initiate the processing of the image data and automatic steering of the vehicle. However, the automatic maintenance of a given distance from a preceding, leading vehicle is not described in the above U.S. No. Pat. 5,245,422.

In heavy-traffic situations, it often happens that one vehicle in a column follows another traveling at a lower speed, e.g. less than 20 kmh, in the same lane. In such situations, the driver's attention is focused primarily on maintaining a given distance from the preceding driver, so as to have an adequate stopping distance in the event of sudden braking. At such low speeds and with the vehicles moving steadily, minor corrections, if any, are all that is needed in order to steer the vehicle. When these driving situations persist for a relatively long period of time, they often cause fatigue or distraction on the part of the driver, since they claim only a small share of his attention.

OBJECTS AND ADVANTAGES OF THE INVENTION

The object of the invention is to make possible a system for automatic following guidance, particularly for heavy-traffic following guidance, of a motor vehicle, which can effectively ease the burden on the driver in certain situations, for example in heavy-traffic situations, by taking over lateral guidance and spacing guidance with respect to a leading vehicle.

A prerequisite for such a system for automatic following guidance, particularly for heavy-traffic automatic following guidance, of a motor vehicle, is an automatic cruise control system with a "stop" and "go" function, which under predetermined conditions makes it unnecessary for the driver to operate the brake, gas and clutch pedals and which, in dependence on specific situations, permits automatic stopping, starting and travel up to a defined limiting speed, independently of actions by the driver. A further prerequisite for the functioning of such a system for automatic following guidance, particularly for heavy-traffic automatic following guidance, of a motor vehicle, is an automatic steering control or regulation system that can impose steering movements and/or steering torques on the steered wheels independently of any actuation of the steering wheel by the driver. A further prerequisite of the system according to the invention for automatic following guidance, particularly for heavy-traffic automatic following guidance, of a motor vehicle is the presence of lane markings and a leading vehicle that is within the lane markings and is moving slowly in the case of heavy traffic. The system vehicle follows the leading vehicle for as long as it travels within the lane markings and below a limiting speed. If the leading vehicle removes itself from consideration, for example by leaving the lane or exceeding the limiting speed, the system deactivates. The same applies when the lane can no longer be detected by means of the environmental image acquisition unit equipped with a video camera and a downstream image analyzer, for example if lane markings are no longer present or are ambiguous. A warning signal informs the driver of each impending deactivation of the automatic following guidance system, particularly of the heavy-traffic automatic following guidance system.

The system of the invention for automatic following guidance, particularly for heavy-traffic automatic following guidance, of a motor vehicle comprises selection and decision means which, on the one hand, decide on the basis of parameters that can be input by and/or are dependent on the driver and on the basis of conditions determined automatically by the system whether automatic following guidance is feasible or whether manual cruise, braking and steering control/regulation must be performed by the driver, whether only automatic guidance along a marked, recognized lane or following guidance based on a recognized leading vehicle or a combination of these types of automatic guidance is feasible, and which, on the other hand, also select on the basis of parameters that can be input by and/or are dependent on a driver and on the basis of conditions determined automatically by the system which of the parameters are to be used to decide between automatic and manual following guidance, and which, if automatic following guidance is performed, select the regulating parameters for cruise, braking and steering regulation.

In the system according to the invention for automatic following guidance, particularly for heavy-traffic automatic

following guidance, of a motor vehicle, the following switching conditions are realized in the form of AND criteria:

The system is active only when the automatic cruise control/regulation system with "stop" and "go" control is active. The automatic "stop" and "go" control requires a release by the driver in order to start moving again after a stop.

The lane markings have been detected unequivocally by the environmental image acquisition unit. I.e., the lane recognition system detects, for example, two broken lines spaced up to 12 m apart, for example. Additionally or alternatively, sufficiently high curbs, for example projecting at least 10 cm above the surface of the road, can be recognized as the lane boundary for short distances.

The leading vehicle is present and has been recognized unequivocally by the environmental image acquisition unit.

The speed of the leading vehicle is below the limiting speed, i.e., below 20–30 km/h, for example.

The selection and decision means of the invention further realizes the following deactivation conditions as "OR" criteria:

if the activation conditions are not or are no longer present;

if the driver performs a steering action beyond a certain steering torque or a floor-pedal action, i.e., an action on the brake pedal, gas pedal or clutch pedal;

if the driver deactivates the system for automatic following guidance of a motor vehicle, e.g. by actuating a switch. In this case the system must deactivate immediately;

if lane markings are not or cease to be present or cannot be recognized unequivocally, or if the lane markings are present but there is no leading vehicle. In this case, after outputting a deactivation warning signal, the vehicle brakes to a stop with no action by the driver and the system deactivates after a defined waiting time, e.g. 1–2 s. The automatic braking operation is interrupted by any intervention on the part of the driver, whether on the steering wheel or on the accelerator or brake pedal, or by deactivation of the automatic cruise control;

if the limiting speed is reached. In this case, the system initially remains active and the system vehicle does not accelerate past the limiting speed. If the leading vehicle then leaves the control range of the system by increasing its speed, the system deactivates, after first giving a deactivation warning signal, since there truly is no longer a leading vehicle in this case.

Regardless of the manner of deactivation, the driver must be able to assume control of the vehicle at any time. Optionally, the automatic cruise control/regulation system can be deactivated along with the deactivation of the automatic steering control/regulation system.

The system of the invention for automatic following guidance, particularly for heavy-traffic automatic following guidance, of a motor vehicle, can be arranged to generate the following information signals and warning signals:

information signals can be generated if implausible driving by the leading vehicle within the recognized lane marking is detected, for

example if the leading vehicle swerves or starts to make a lane change.

A deactivation warning can be generated before each system deactivation.

The system of the invention for automatic following guidance, particularly for heavy-traffic automatic following guidance, of a motor vehicle permits a modular and expandable, hierarchically organized controller structure that offers situation recognition by the system and/or by the driver and situation-dependent decision-making and selection via the control/regulating mode, i.e., manual or automatic control, selection of the type of control or regulation, i.e., lane following or following behind the leading vehicle, and selection of the controller parameters and the setpoint values for the regulating system.

Also optionally provided is a driver-type recognition unit that brings about driver-adaptive adjustment of the system. The driver has the highest priority in every case and can assume control of the system at any time, since he is always in the monitoring loop.

The claimed environmental recognition unit preferably operates by means of radar (Radio Detection and Ranging) and/or lidar (Light Detection and Ranging) emission.

A preferred embodiment of a system according to the invention for automatic following guidance of a motor vehicle is described in more detail hereinbelow with reference to the drawing. The invention is elucidated in particular with reference to automatic following guidance in heavy traffic.

DRAWING

FIG. 1 is a functional block diagram that provides an overview of the structure of the system according to the invention; and

FIG. 2, also a functional block diagram, depicts a controller structure of the system according to the invention, divided into longitudinal and lateral guidance functions.

EXEMPLARY EMBODIMENT

As is shown in FIG. 1 by the functional block diagram of the system according to the invention for heavy-traffic automatic following guidance, the controller structure is organized in hierarchical fashion. The levels of the hierarchy are identified in FIG. 1 as I, II, III and IV.

The lowest hierarchical level I includes the motor vehicle 1 with its assigned sensors 2 and final control elements 3. The sensors 2 include in particular the video camera, optionally with the downstream image analyzer and the spacing recognition sensor implemented by means of a radar system, for example, as well as other sensors present in the vehicle, for example a sensor for determining the actual vehicle speed, an acceleration sensor, a slope sensor, a lateral acceleration sensor, etc. Also included are sensors that detect the steering-wheel angle imposed at the steering wheel and the actual steering angle to which the wheels to be steered are adjusted by means of the automatic steering control/regulation system. The sensors mentioned here are merely examples. Corresponding signals can also be supplied by other control units present in the vehicle.

The final control elements 3 serve to control the longitudinal and lateral movement of the vehicle independently of the type of drive. For example, final control elements can be provided for control/regulation of the internal combustion engine, such as its rotation speed, throttle-valve angle, injection quantity and/or injection interval, final control elements for automatic or manual braking, and one or more electric servomotors for adjusting a steering angle at the steered wheels independently of the steering-wheel angle.

The next hierarchical level II represents the basic control/regulation system and comprises a state estimator 4 acted on

by the signals supplied by sensors 2, selectable controller types or control laws for forward controls 5, and selectable controller types or control laws for regeneration controls 6, the selected controller types/control laws being compiled via an adder, as well as a reversing switch 7 that switches between automatic and manual driving of the final control elements 3. The control laws of the forward control 5 and those of the regeneration control 6 use results from the state estimator 4 and from unit 8, which has the function of adapting the controller parameters and the setpoint values, and are selected independently of results affecting a control-mode selection unit 9. Units 8 and 9 are assigned to the next-higher level III of the hierarchy. In the highest hierarchical level IV, which performs the functions of monitoring and adaptation, a unit 10 analyzes the situation based on the results supplied by the state estimator 4, sensor signals from the control sensors 2, and driver inputs, and generates an analytical result that is processed in a decision unit 12 and contributes substantially to the decision as to whether manual or automatic control or regulation is to be carried out for heavy-traffic automatic following guidance. The situation analyzed by unit 10 is further used, via a unit 11, to select the controller mode by means of selection unit 9, particularly to determine whether following guidance with respect to a preceding leading vehicle or guidance with respect to the lane markings is to be performed.

The highest hierarchical level IV optionally includes an adaptive driver-type recognition system that acts on the setpoint-value and parameter adaptation unit 8 in accordance with a recognized driver type. Such adaptive driver-type recognition can also be replaced or supplemented by appropriate driver-type information input by the driver himself.

Thus, by directly influencing situation analyzer 10 and reversing switch 7, the driver is able at any time

to adapt the heavy-traffic automatic following guidance of the system to the existing situation or to deactivate it and drive the vehicle manually. Because the driver spans levels II–IV of the hierarchy, he himself has the highest priority and can override the system at any time. As a result of the situation analysis 10, which can be influenced at the driver's discretion and is acted upon by the sensor signals, a situation-dependent decision is reached concerning the control/regulation mode, "manual" or "automatic," the type of control or regulation, e.g. based on the recognized lane marking or based on the recognized leading vehicle, and, via units 8 and 9, the choice of the parameters and setpoint values (units 5 and 6) for the control/regulation system. The optionally provided driver-type recognition unit 13 permits driver-adaptive adjustment by acting on the setpoint-value and parameter adaptation unit 8.

The system for heavy-traffic automatic following guidance explained with reference to the functional block diagram shown in FIG. 1 advantageously has a hierarchical and expandable structure and functions in a situation- and driver-adaptive manner in which the driver is always in the monitoring loop, has the highest priority and can override the system at any time. Thus, the driver can at any time assess the traffic situation himself and assume responsibility for his vehicle by deactivating the heavy-traffic automatic following guidance system.

The hierarchically organized functional structure of the system of the invention for heavy-traffic automatic following guidance shown in FIG. 1 is depicted further in FIG. 2, again in the form of a functional block diagram, which divides the functions according to the invention into cruise and braking control or regulation A (in the lefthand portion of FIG. 2) and automatic steering control/regulation B (in the righthand portion of FIG. 2).

Cruise and Braking Control and Regulation System with "Stop" and "Go" Function

Entered in the upper portion of Section A are the cruise and braking control and regulation functions assigned directly to the vehicle 1, i.e., final control elements 120 and sensors, in particular a sensor 121 for detecting the vehicle speed. The measured vehicle speed is input along with a set desired speed 124 to a speed regulator 123, which acts on a selection function 122 for selecting the regulating mode. Additional input variables of the cruise and braking control or regulation system A are a time spacing with respect to the leading vehicle 125, vehicles 129 detected by a radar system 126, and detected lane markings 128, which are a result of the analysis of image frames supplied by a video camera 127. Based on the detected lane marking 128 and the detected vehicles 129, the selection function 130 selects an appropriate preceding leading vehicle (output variable 131). Additional output variables from the vehicle selector 130 are the relative speed 132 and the distance 133 of the preceding vehicle from the system vehicle. The actual distance 133 determined in this way is combined with the desired distance computed from the measured speed of the system vehicle, and the combined result acts upon a distance-regulating function 134, which also receives as an input variable the relative speed 132 resulting from the selection function 130. In a selection function 122, the control or regulating mode of the cruise and braking control or regulation system A is selected, i.e., either speed regulation 123 or distance regulation 134, in order to drive the final control element 120.

Automatic Steering Control/Regulation System B

The automatic steering control/regulation system B, shown in the righthand portion of FIG. 2, again includes the cross-hatched level of vehicle 1 with the final control elements 20 assigned to the vehicle and needed for automatic steering control or regulation, together with sensors 21 for detecting the actual position of the system vehicle. Regulating part B receives as input variables the information 131 regarding the detected leading vehicle, the actual distance 133 between the system vehicle and the leading vehicle, and the lane markings 128 acquired from the analyzed image frames from the video camera 127. From the actual position of the driver's vehicle, supplied by sensors 21, and the lane markings 128 acquired from the image frames of the video camera, a selection function 27 selects the appropriate lane marking for automatic steering control or regulation B. If this is a lane marking 24 in front of the system vehicle, this information 24, together with the information 131 from the lefthand regulating part A concerning the detected preceding leading vehicle, acts on a selection function 23 to select the regulating mode, which, by means of a selection function depicted symbolically as reversing switch 31, chooses whether the automatic steering control or regulation B is to be leading-vehicle following regulation 26 or lane-marking following regulation 29. The leading-vehicle following regulation system 26 receives as an input variable the distance 133, determined in Part A, of the system vehicle from the preceding leading vehicle and a setpoint value 25, whereas the lane-marking following regulation system 29 receives from selection function 27 a datum concerning a suitable selected lane marking 28 and a setpoint value 30. The final control elements 20 are then adjusted according to the automatic steering control or regulating mode selected by the selection function 31, i.e., either according to leading vehicle following regulation 26 or lane-marking following regulation 29.

It should be mentioned that the functions organized hierarchically according to FIG. 1 and according to regulating modes A and B in FIG. 2 can be performed by a suitably arranged control/regulating unit. However, it goes without saying that the functions can also be performed by separate control/regulating units whose programs are organized according to the separate functions A and B shown in FIG. 2.

An embodiment of the system of the invention for automatic following guidance of a motor vehicle in heavy traffic can include the following operating elements and displays:

on/off switch

optionally a keyboard for inputting driver-type information, which, as stated, can replace or supplement the automatic driver-type recognition unit **13**;

display: "System is ready for use," i.e., the conditions for its activation have been met;

display: "System is active";

display: "System is (will be) deactivated."

The following list gives by way of example some situations, the ensuing system responses, and data that are communicated to a driver:

A leading vehicle that is moving from side to side in the lane, i.e., the leading vehicle is swerving or is traveling in an implausible manner. Information to this effect is displayed to the driver. The system can then use its built-in intelligence and watch for obstacles and respond autonomously. Appropriate threshold values are needed for this purpose.

A lane change by the leading vehicle with immediate recognition of a new leading vehicle. Corresponding information is generated for the driver.

Cutting in by a vehicle, in which case the vehicle cutting in becomes a new leading vehicle. Information to this effect is displayed to the driver of the system vehicle. If a vehicle cuts in too closely, braking is necessary, for example at more than 0.5 g. For this purpose, the automatic steering system allows an additional degree of freedom for swerving.

A lane change by the leading vehicle with no recognition of a new leading vehicle. The system is deactivated and a corresponding deactivation warning is generated and displayed. In the event of a sudden lane change by the leading vehicle, for example to avoid an obstacle, the dead time can be shortened or the maximum delay increased. If an object or a leading vehicle is then recognized reliably, the maximum deceleration of 0.5 g can be increased.

The lane marking can no longer be detected, but a leading vehicle is still present. The system then deactivates with a deactivation warning.

Stationary objects that are not vehicles, e.g. electronic flares, construction barriers, lost loads, are in the lane. If these objects have been detected reliably, the system can respond by deactivating with a deactivation warning.

An intersection is recognized by the absence or discontinuation of the lane marking. The system can then deactivate with a deactivation warning.

As a development of the invention, a model of the environment can be created in the system and the path of the lane can be calculated in advance by this means. This ensures that the system will be able to respond to greater distances between lane markings, e.g. if they are covered with snow, or to leading vehicles that are not traveling in alignment.

A suitably adjusted aperture for the video camera and/or the use of a plurality of spaced-apart video cameras ensures the recognition of situations that would otherwise be unclear.

What is claimed is:

1. A guidance system for a motor vehicle which comprises

an electronic cruise, braking and steering control/regulation system;

at least one of an environmental image acquisition unit which includes a video camera and an image analyzer for generating signals that are used to control said electronic cruise, braking and steering control/regulation system for automatic guidance of said vehicle along a marked lane, and an environmental detector that detects reflections of emitted electromagnetic radiation;

a spacing and relative speed processor coupled to at least one of said environmental image acquisition unit and said environmental detector for receiving output signals therefrom and determining from said output signals spacing and relative speed of said vehicle with respect to a lead vehicle, said spacing and relative speed processor further generating spacing and relative speed signals;

a control mode selector and a decision maker both of which are coupled to said spacing and relative speed processor for receiving said spacing and relative speed signals; and

a driver input coupled to said control mode selector and said decision maker for inputting driver information into said control mode selector and said decision maker,

said decision maker determining whether to allow manual or automatic guidance control of said vehicle, and

said control mode selector determining parameters that are used to control said electronic cruise, braking and steering control/regulation system.

2. The guidance system for a motor vehicle according to claim 1, wherein said decision maker further determines whether to conduct automatic guidance of said vehicle using lane markings.

3. The guidance system for a motor vehicle according to claim 1, wherein said decision maker further determines whether to conduct automatic guidance of said vehicle using the spacing and relative speed of said lead vehicle.

4. The guidance system for a motor vehicle according to claim 1, further comprising a control signal adjuster that is coupled to said control mode selector and adjusts control signals therefrom based upon at least one of set points and inputted driver information.

5. The guidance system for a motor vehicle according to claim 1, further comprising a driver-type recognizer which is coupled to said control signal adjuster and forwards signals thereto which correspond to different drivers.

6. The guidance system for a motor vehicle according to claim 1, wherein said decision maker activates automatic following guidance only when said environmental image acquisition unit has recognized marked lanes and has ascertained that a lead vehicle is traveling within said recognized marked lanes.

7. The guidance system for a motor vehicle according to claim 1, wherein said decision maker activates automatic following guidance only when a lead vehicle is traveling below a limiting speed.

8. The guidance system for a motor vehicle according to claim 1, wherein said decision maker activates automatic

following guidance only when a driver activates said system after a stop and restart.

9. The guidance system for a motor vehicle according to claim 1, wherein said decision maker deactivates automatic following guidance when a lead vehicle departs from a marked lane and no new lead vehicle is recognized or traveling faster than a limiting speed.

10. The guidance system for a motor vehicle according to claim 1, wherein said decision maker deactivates automatic following guidance when a driver performs a steering maneuver that exceeds at least one of a specified steering torque and a specified steering angle.

11. The guidance system for a motor vehicle according to claim 1, wherein said decision maker deactivates automatic following guidance when a driver manipulates an accelerator pedal of said vehicle.

12. The guidance system for a motor vehicle according to claim 1, wherein said decision maker deactivates automatic following guidance when a driver has activated said system but conditions for activation are not met.

13. The guidance system for a motor vehicle according to claim 1, wherein said decision maker deactivates automatic following guidance upon a manual input by a driver.

14. The guidance system for a motor vehicle according to claim 1, wherein said decision maker deactivates automatic following guidance when said environmental image acquisition unit has ascertained that no lane markings are present.

15. The guidance system for a motor vehicle according to claim 1, further comprising a warning signal generator that produces a warning signal for a driver upon deactivation of automatic following guidance.

16. The guidance system for a motor vehicle according to claim 1, wherein said spacing and relative speed processor comprises a radar detector.

17. The guidance system for a motor vehicle according to claim 1, wherein said environmental detection unit comprises at least one of a radar detector and a lidar detector.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,370,471 B1
DATED : April 9, 2002
INVENTOR(S) : Herbert Lohner et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [57], please delete the **ABSTRACT** and in place thereof, substitute the following **ABSTRACT**:

-- An automatic following guidance system for motor vehicles that includes an electronic cruise, braking and steering control/regulation system, and an environmental image acquisition unit equipped with a video camera and an image analysis means for generating signals that can be input to the electronic cruise, braking and steering control system at least for automatic guidance along a marked traffic lane. In addition to, or alternatively to the video camera and image analysis means, the system can include an environmental detection unit operating on the basis of detected reflections of emitted electromagnetic radiation. The system further includes a spacing and relative-speed detection unit that detects spacing and a relative speed with respect to a leading vehicle selectable on the basis of signals generated by the environmental image acquisition unit and generates in each case a corresponding spacing and relative speed detection signal. --

Signed and Sealed this

Third Day of September, 2002

Attest:

JAMES E. ROGAN

Attesting Officer

Director of the United States Patent and Trademark Office

First Hit Fwd Refs Previous Doc Next Doc Go to Doc#

End of Result Set

Generate Collection Print

L24: Entry 1 of 1 File: USPT Apr 9, 2002

DOCUMENT-IDENTIFIER: US 6370471 B1

**** See image for Certificate of Correction ****

TITLE: Automatic following guidance system for motor vehicles

Detailed Description Text (4):

15

The final control elements 3 serve to control the longitudinal and lateral movement of the vehicle independently of the type of drive. For example, final control elements can be provided for control/regulation of the internal combustion engine, such as its rotation speed, throttle-valve angle, injection quantity and/or injection interval, final control elements for automatic or manual braking, and one or more electric servomotors for adjusting a steering angle at the steered wheels independently of the steering-wheel angle.

Previous Doc Next Doc Go to Doc#

L2: Entry 1 of 1 File: USPT Nov 21, 2000

DOCUMENT-IDENTIFIER: US 6151539 A
TITLE: Autonomous vehicle arrangement and method for controlling an autonomous vehicle

Detailed Description Text (24):
In addition to the vehicle path as such, the optimal path also includes information on the permissible maximum speeds for individual route segments, which lane should be selected, the radii of curves, traffic lights, right-of-way signs, stop signs, intersections, and where and how turns must be made. Such very precise information is necessary since the autonomous vehicle cannot act intuitively as a human being can. For example, even though he soon will have to turn left, a human driver drives as long as possible in the right or center lane so that he will not be obstructed by vehicles turning left at preceding intersections, and then switches to the left turning lane depending on the traffic situation. The other information is necessary so that the autonomous vehicle can adapt its driving behavior in a timely fashion. This is important particularly with regard to other traffic participants, for whom very abrupt driving behavior is irritating and could lead to incorrect judgments. Since not all information regarding the infrastructure is contained as advance information in the digital map 33, for instance because new traffic signs have been installed, the vehicle path control unit 34 is additionally supplied with the acquired sensor signals from the sensors 1-20, from which additional infrastructure information can be taken, for example the traffic signs detected by the video camera 10 or the weather conditions detected by the sensors 16-18, upon which the maximum permissible speed can depend, for example. The optimal vehicle path, which one could also refer to as a virtual ideal control wire, is determined from all this information. The generated ideal path is transmitted together with the current visual sensor information from the sensors 9-13 and 20.

steering

L17: Entry 1 of 1 File: USPT Jul 8, 2003

DOCUMENT-IDENTIFIER: US 6591172 B2
TITLE: AUTOMATIC VEHICLE GUIDANCE SYSTEM, CONTROL APPARATUS IN AUTOMATIC VEHICLE GUIDANCE SYSTEM, AUTOMATIC VEHICLE GUIDANCE METHOD, AND COMPUTER-READABLE DATA RECORDED MEDIUM IN WHICH AUTOMATIC VEHICLE GUIDANCE SYSTEM PROGRAM IS RECORDED

Abstract Text (1):
An automatic guidance system is comprised of a navigation apparatus mounted on a vehicle and a control server apparatus fixedly installed in an automatic travel control center which controls traveling in an automatic traveling section. The control server apparatus and the navigation apparatus establish a communication line through a mobile communication network. The navigation apparatus makes a search for a route to a destination. If at least part of the automatic traveling section is used in a route set by the search, the automatic traveling section is registered in the control server apparatus through the communication line.

Application Filing Date (1):
20021025

Brief Summary Text (3):
The present invention relates to techniques for automatic-drive traveling of a vehicle in techniques relating to intelligent transport systems (ITS) and, more particularly, to a technique for registering an automatic traveling route for a vehicle by using a navigation system.

Brief Summary Text (5):
In recent years, techniques have been realized which relate to intelligent transport systems (ITS) in which automatic toll payment and collection operations (in an automatic toll collection system) are performed by transmitting and receiving data between a vehicle and apparatuses installed on roads by mobile communication system. Studies of other techniques relating to ITS, i.e., techniques for support to careful driving, optimization of traffic control, etc. have also been advanced. In particular, studies of a kind of automatic guidance system relating to automatic traveling are being advanced by experiments based on traveling of actual vehicles. In the automatic guidance system, a driver does not perform driving operations but traveling of a vehicle such as a automobile in which the driver is riding is controlled in guiding the traveling vehicle.

Brief Summary Text (6):
For realization of such an automatic guidance system, building of infrastructures including roads is required as well as providing special-purpose equipment in vehicles. Possible forms of roads on which automatic traveling is performed include one in which particular travel paths are set as automatic traveling sections in which only vehicles capable of complete automatic traveling can be made to travel, and one in which an automatic traveling section and a non-automatic traveling section in which vehicles travel ordinarily by being operated by drivers are set in parallel with each other. That is, even if an automatic guidance system is realized, automatic traveling of all vehicles in operation is not possible at an initial stage of implementation of the system or automatic traveling cannot be

performed on some roads, and conventional sections in which vehicles are manually driven by drivers and vehicles driven by drivers in the conventional manner coexist.. For this reason, the above-described forms of roads are conceivable.

Brief Summary Text (7):
Therefore, techniques for changeover between automatic traveling and non-automatic traveling are considered particularly important among techniques for realizing automatic traveling at an initial stage of implementation of an automatic guidance system. Techniques for changeover between automatic traveling and non-automatic traveling are known, which include a typical automatic operation control apparatus disclosed in Japanese Patent Laid-Open Publication No. 2000-276690.

Brief Summary Text (8):
The conventional automatic operation control apparatus, however, requires a driver's operation for changing the vehicle traveling mode from the automatic-drive traveling mode to the normal-drive traveling mode during automatic-drive traveling. If the driver misses a point at which changeover from automatic-drive traveling to normal-drive traveling should be made, there is a possibility that the vehicle cannot travel the route on which the vehicle should travel.

Brief Summary Text (9):
Also, it is thought that in the case where a driver previously sets points at which the vehicle traveling mode should be changed from automatic-drive traveling to normal-drive traveling, troublesome operations for setting of an exit point etc. are required.

Brief Summary Text (12):
The above object of present invention can be achieved by an automatic vehicle guidance system of the present invention. The automatic vehicle system for guiding a vehicle which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path is provided with: a control device for managing the automatic traveling section, and controlling the vehicle traveling in the automatic traveling section; an acquisition device for obtaining present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search device for making a search for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; and a registration device for registering the automatic traveling path which is included in the travel route if at least part of the automatic traveling section is included in the travel route as a result of the route search, and the control device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

Brief Summary Text (13):
According to the present invention, if at least part of the automatic traveling section is used as a travel route as a result of the route search for a travel route to the destination which is to be reached by the vehicle, the automatic traveling path to be used is registered and automatic traveling of the vehicle is controlled by a control apparatus along the automatic traveling path when the vehicle travels in the automatic traveling section, thereby performing automatic guidance of the vehicle.

Brief Summary Text (21):
Accordingly, entry into the automatic traveling section and exit from the automatic traveling section when the vehicle travels in the automatic traveling section can be controlled with reliability.

Brief Summary Text (22):
Since each vehicle can be easily identified from the identification data, automatic

traveling control can be correctly performed with respect to each vehicle, thus enabling management on the automatic traveling section to be performed smoothly.

Brief Summary Text (23):
In one aspect of the present invention, in a case where at least one of the entry point data and the exit point data is registered by the registration device, the automatic vehicle guidance system is further provided with: a receiving device for receiving arrival data indicating that the vehicle reaches at least one of the entry point and the exit point, and the control device controls at least one of starting and termination of automatic traveling of the vehicle on the basis of the arrival data.

Brief Summary Text (24):
According to the present invention, in a case where the controlled vehicle traveling in the automatic traveling section reaches the entry point or the exit point after the entry point data and the exit point data is registered by the registration device, if at least part of the automatic traveling section is included in the travel route as a result of the route search, the control device controls starting or termination of automatic traveling of the vehicle.

Brief Summary Text (25):
Accordingly, entry into the automatic traveling section and exit from the automatic traveling section when the vehicle travels in the automatic traveling section can be controlled with reliability, thus enabling management on the automatic traveling section to be performed smoothly.

Brief Summary Text (26):
In one aspect of the present invention, in a case where at least one of the entry point data and the exit point data is registered by the registration device the automatic vehicle guidance system is further provided with: a detection device for detecting at least one of changeover of the traveling mode from the automatic traveling to normal-drive traveling based on manual operations, and changeover of the traveling mode from the normal-drive traveling to the automatic traveling, and the control device controls at least one of starting and termination of automatic traveling of the vehicle when the detection device detects at least one of changeover of the traveling mode at the entry point, and changeover of the traveling mode at the exit point.

Brief Summary Text (27):
According to the present invention, starting or termination of automatic traveling is controlled when changeover of the traveling mode at the entry point or the exit point is detected.

Brief Summary Text (28):
Accordingly, if changeover of the traveling mode is detected when the vehicle enters the automatic traveling section or exits from the automatic traveling section, automatic traveling can be started or terminated. For example, if the traveling mode is not changed to normal-drive traveling after the completion of traveling through the automatic traveling section, the vehicle is not allowed to enter a normal-drive traveling path but made to turn aside into a parking area or the like. Thus, safety of the vehicle traveling in both automatic and non-automatic traveling sections can be ensured without requiring any troublesome operation.

Brief Summary Text (29):
In one aspect of the present invention, the automatic vehicle guidance system is further provided with: the detection device detects changeover of the traveling mode based on condition data of the driver who is operating the vehicle.

Brief Summary Text (30):
According to the present invention, it is possible to prevent the vehicle from

exiting from the automatic traveling section into a non-automatic traveling section when the driver is unable to operate the vehicle, thus ensuring safety of the vehicle traveling in both automatic and non-automatic traveling sections.

Brief Summary Text (31):
In one aspect of the present invention, the automatic vehicle guidance system is further provided with: the condition data has bodily data indicating condition which is included at least one of an awake condition and an asleep condition of driver, and the detection device detects changeover of the traveling mode based on the bodily data.

Brief Summary Text (32):
According to the present invention, it is possible to prevent the vehicle from exiting from the automatic traveling section into a non-automatic traveling section when normal driving is not possible, thus ensuring safety of the vehicle traveling in both automatic and non-automatic traveling sections.

Brief Summary Text (37):
In one aspect of the present invention, the automatic vehicle guidance system is further provided with: the navigation system comprises an data server device fixedly installed, and a communication terminal device mounted on the vehicle and communicating with the data server device through a mobile communication network, the communication terminal device and the data server device communicate with each other to perform navigation of the vehicle, the data server device and the registration device communicate with each other to register the automatic traveling path which is included in the travel route as a result of the route search, and the control device performs automatic guidance of the vehicle traveling in the automatic traveling section.

Brief Summary Text (39):
The above object of present invention can be achieved by a control apparatus for an automatic vehicle guidance system for guiding a vehicle which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path of the present invention. The control apparatus is provided with: a control device for managing the automatic traveling section and controlling the vehicle traveling in the automatic traveling section; a route data acquisition device for obtaining route data indicating a travel route to destination to be reached by the vehicle as a result of route search based on present position data of the vehicle, and destination data indicating a destination to be reached by the vehicle; and a registration device for registering the automatic traveling path which is included in the travel route if at least part of the automatic traveling section is included in the travel route as a result of the route search, and the control device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

Brief Summary Text (40):
According to the present invention, if at least part of the automatic traveling section is used as a travel route as a result of the route search for a travel route to the destination which is to be reached by the vehicle, the automatic traveling path to be used is registered and automatic traveling of the vehicle is controlled by a control apparatus along the automatic traveling path when the vehicle travels in the automatic traveling section, thereby performing automatic guidance of the vehicle.

Brief Summary Text (43):
In one aspect of the present invention, the control apparatus is further provided with: if a travel route to the destination is set by the re-search while the vehicle is traveling in the automatic traveling section, the registration device reregisters the automatic traveling path on the basis of the travel route set by

the re-search.

Brief Summary Text (46):
In one aspect of the present invention, the control apparatus is further provided with: when the registration device registers the automatic traveling path, it registers at least one of the identification data of the vehicle, entry point data indicating an entry point at which the vehicle enters the automatic traveling section, and exit point data indicating an exit point at which the vehicle exits from the automatic traveling section.

Brief Summary Text (48):
Accordingly, entry into the automatic traveling section and exit from the automatic traveling section when the vehicle travels in the automatic traveling section can be controlled with reliability.

Brief Summary Text (49):
Since each vehicle can be easily identified from the identification data, automatic traveling control can be correctly performed with respect to each vehicle, thus enabling management on the automatic traveling section to be performed smoothly.

Brief Summary Text (50):
In one aspect of the present invention, in a case where at least one of the entry point data and the exit point data is registered by the registration device, the control apparatus is further provided with: a receiving device for receiving arrival data indicating that the vehicle reaches at least one of the entry point and the exit point, the control device controls at least one of starting and termination of automatic traveling of the vehicle on the basis of the arrival data.

Brief Summary Text (51):
According to the present invention, in a case where the controlled vehicle traveling in the automatic traveling section reaches the entry point or the exit point after the entry point data and the exit point data is registered by the registration device if at least part of the automatic traveling section is included in the travel route as a result of the route search, the control device controls starting or termination of automatic traveling of the vehicle.

Brief Summary Text (52):
Accordingly, entry into the automatic traveling section and exit from the automatic traveling section when the vehicle travels in the automatic traveling section can be controlled with reliability, thus enabling management on the automatic traveling section to be performed smoothly.

Brief Summary Text (53):
In one aspect of the present invention, in a case where at least one of the entry point data and the exit point data is registered by the registration device, the control apparatus is further provided with: a changeover data acquisition device obtains changeover data which includes at least one of data indicating changeover of the traveling mode from the automatic traveling to normal-drive traveling based on manual operations in the vehicle, and data indicating changeover of the traveling mode from the normal-drive traveling to the automatic traveling in the vehicle, the control device controls at least one of starting and termination of automatic traveling of the vehicle when the changeover data acquisition device obtains the changeover data.

Brief Summary Text (54):
According to the present invention, starting or termination of automatic traveling is controlled when changeover of the traveling mode at the entry point or the exit point is detected.

Brief Summary Text (55):
Accordingly, if changeover of the traveling mode is detected when the vehicle enters the automatic traveling section or exits from the automatic traveling section, automatic traveling can be started or terminated. For example, if the traveling mode is not changed to normal-drive traveling after the completion of traveling through the automatic traveling section, the vehicle is not allowed to enter a normal-drive traveling path but made to turn aside into a parking area or the like. Thus, safety of the vehicle traveling in both automatic and non-automatic traveling sections can be ensured without requiring any troublesome operation.

Brief Summary Text (56):
In one aspect of the present invention, the control apparatus is further provided with: the registration device registers the automatic traveling path previously before the vehicle enters the automatic traveling section.

Brief Summary Text (58):
The above object of present invention can be achieved by an automatic vehicle guidance method of the present invention. The automatic vehicle method, in which automatic guidance of a vehicle is performed by controlling traveling of the vehicle in an automatic traveling section which is a travel path on which the vehicle travels in an automatic traveling manner without being operated by a driver, is provided with: an acquisition process of obtaining present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search process of making a search for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; a registration process of registering the automatic traveling path which is included in the travel route if at least part of the automatic traveling section is included in the travel route as a result of the route search; and an automatic guidance process of controlling automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

Brief Summary Text (59):
According to the present invention, if at least part of the automatic traveling section is used as a travel route as a result of the route search for a travel route to the destination which is to be reached by the vehicle, the automatic traveling path to be used is registered and automatic traveling of the vehicle is controlled along the automatic traveling path when the vehicle travels in the automatic traveling section, thereby performing automatic guidance of the vehicle.

Brief Summary Text (67):
Accordingly, entry into the automatic traveling section and exit from the automatic traveling section when the vehicle travels in the automatic traveling section can be controlled with reliability.

Brief Summary Text (68):
Since each vehicle can be easily identified from the identification data, automatic traveling control can be correctly performed with respect to each vehicle, thus enabling management on the automatic traveling section to be performed smoothly.

Brief Summary Text (71):
The above object of present invention can be achieved by a data recorded medium of the present inversion automatic vehicle guidance system of the present invention wherein an automatic vehicle guidance program is recorded so as to be read by a computer, the computer included in an automatic vehicle guidance system for guiding a vehicle which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path, the automatic vehicle guidance program causing the computer to function as: a control device manages the automatic traveling section and controls the vehicle traveling in the automatic traveling section; an acquisition device obtains present

position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search device makes a search for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; and a registration device registers the automatic traveling path which is included in the travel route if at least part of the automatic traveling section is included in the travel route as a result of the route search; and an automatic guidance device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

Brief Summary Text (72):
According to the present invention, if at least part of the automatic traveling section is used as a travel route as a result of the route search for a travel route to the destination which is to be reached by the vehicle, the automatic traveling path to be used is registered and automatic traveling of the vehicle is controlled by a control apparatus along the automatic traveling path when the vehicle travels in the automatic traveling section, thereby performing automatic guidance of the vehicle.

Brief Summary Text (80):
Accordingly, entry into the automatic traveling section and exit from the automatic traveling section when the vehicle travels in the automatic traveling section can be controlled with reliability.

Brief Summary Text (81):
Since each vehicle can be easily identified from the identification data, automatic traveling control can be correctly performed with respect to each vehicle, thus enabling management on the automatic traveling section to be performed smoothly.

Drawing Description Text (7):
FIGS. 6A, 6B, and 6C are diagrams each showing an example of a changeover notice displayed on a display unit at the time of changeover from automatic traveling to normal-drive traveling in the embodiment of the present invention;

Drawing Description Text (9):
FIG. 8 is a block diagram showing a configuration of a conventional automatic operation control apparatus.

Detailed Description Text (3):
An embodiment of the present invention described below is an application of the present invention to an automatic vehicle guidance system which is provided for guidance along a particular automatic traveling section, and which is constituted by a navigation apparatus mounted on a vehicle and a control server apparatus provided in an automatic travel control center for control over the automatic traveling section.

Detailed Description Text (7):
As shown in FIG. 1, the automatic guidance system 100 of this embodiment is constituted by a navigation apparatus 110 mounted on a vehicle, 101, and a control server apparatus 130 provided as a stationary unit in an automatic travel control center for control over an automatic traveling section in which traveling of a vehicle is controlled with no driver's operation. The control server apparatus 130 and the navigation apparatus 110 have a communication line established therebetween through a mobile communication network 102 which includes a public telephone network line or an Internet.

Detailed Description Text (9):
In ordinary cases, at the time of performing automatic control of traveling of vehicles (hereinafter referred to simply as "automatic travel control") in an automatic traveling section, it is necessary to make a registration of each of

vehicles traveling in the automatic traveling section and to cancel the registration of each of the vehicles in order to perform smooth automatic travel control during traveling of the vehicle in the automatic traveling section, i.e., to perform entry control when each vehicle enters the automatic traveling section and exit control when the vehicle exits from the automatic traveling section, and to control traveling of the vehicle 101 according to a route in the automatic traveling section through which the vehicle should travel (hereinafter referred to as "automatic traveling section route").

Detailed Description Text (10):
In this embodiment, therefore, data about the vehicle 101, i.e., position data and route data obtained by the navigation apparatus 110 are transmitted to the control server apparatus 130, and a point at which the vehicle 101 enters the automatic traveling section (start point (hereinafter referred to simply as "entry point")), a point at which the vehicle 101 exits from the automatic traveling section (end point (hereinafter referred to simply as "exit point")), and the automatic traveling section route are computed in the control server apparatus 130 on the basis of the position data and the route data to make a registration of the vehicle 101 at the time of entry and cancellation of the registration at the time of exit.

Detailed Description Text (11):
More specifically, the navigation apparatus 110 makes a search for a route to a destination on the basis of data indicating the destination to be reached by the vehicle 101 on which the navigation apparatus 110 is mounted (hereinafter referred to as "destination data"), the vehicle position data obtained by receiving global positioning system (GPS) data, and mobile data, i.e., vehicle data obtained by various sensors, such as a vehicle speed sensor using vehicle speed pulses, an acceleration sensor, a vibration sensor, and a gyroscope. The navigation apparatus 110 performs navigation of the vehicle 101 by using a search result and these data. If the navigation apparatus 110 selects the automatic traveling section as a portion of a route to the destination as the route search result, it transmits the obtained position data and route data indicating the route search result to the control server apparatus 130 over the communication line when the vehicle reaches a point set in advance.

Detailed Description Text (12):
Furthermore, the control server apparatus 130 controls traveling of each of vehicles in the predetermined automatic traveling section (not shown), makes a registration of a vehicle entering the automatic traveling section, and cancels the registration of a vehicle exiting from the automatic traveling section. The control server apparatus 130 obtains the position data and the route data of the vehicle 101 on which the navigation apparatus 110 is mounted, and sets a point at which the vehicle enters the automatic traveling section, a point at which the vehicle exits from the automatic traveling section, and a route in the automatic traveling section through which the vehicle travels (hereinafter referred to as "automatic traveling route") on the basis of the position data and route data obtained.

Detailed Description Text (13):
In the thus-arranged system of this embodiment, when the automatic traveling section is selected to be used for traveling of the vehicle 101 as a result of a route search made by the navigation apparatus 110, a point (entry point) at which automatic traveling of the vehicle 101 in the automatic traveling section is started and a point (exit point) at which traveling of the vehicle 101 is terminated are determined to enable automatic travel control from the determined entry point to the determined exit point. This entry point and exit point setting can be easily made with reliability. Thus, the operability for the driver, i.e., the user, is improved and improved user support can be achieved.

Detailed Description Text (18):
As shown in FIG. 2, the navigation apparatus 110 is constituted by a GPS receiving

unit 111 which is connected to an antenna AT, and which receives GPS data, a speed/acceleration sensor unit 112 which detects the speed of traveling and acceleration of the vehicle, an azimuth sensor section 113 that senses the azimuth of the vehicle, a VICS data receiving unit 114 which receives VICS data from the vehicle information and communication system (VICS), a map data storage unit 115 in which map data is stored, an operating unit 116, a display unit 117 which displays map data and the position of the vehicle, a speech guidance unit 118 which outputs speeches for guidance, a system control unit 119 for overall control of the system, and a communication unit 120 which is connected to the antenna AT, and which performs communication with the control server apparatus 130.

Detailed Description Text (25):
The map data storage unit 115 stores, in a readable state, map data such as road maps and other sorts of data necessary for travel guidance. For example, the map data storage unit 115 is constituted by a DVD drive which reads out map data or the like from a DVD-read only memory (DVD-ROM) on which data necessary for travel guidance including the map data is stored, or a hard disk having map data etc. stored thereon.

Detailed Description Text (27):
The display unit 117 displays map data output from the map data storage unit 115, and data on various conditions including those relating to travel guidance performed by the navigation apparatus 110, and data on a destination.

Detailed Description Text (28):
The speech guidance unit 118 outputs, in speech form, travel route guidance data. The travel route guidance data include data on the vehicle traveling direction from the next intersection, and data to be notified directly to the driver in guidance (congestion data, road closure data, etc.).

Detailed Description Text (30):
The system control unit 119 controls display unit 117 etc. so that the above-described travel route guidance data is displayed on display unit 117 in a map on which the present position of the vehicle is shown in a peripheral area on the basis of traveling data (vehicle position and speed data) obtained by a position computation unit (not shown). The system control unit 119 also controls the speech guidance unit 118 etc. so that corresponding travel route guidance data or the like is output as a speech from the speech guidance unit 118.

Detailed Description Text (32):
More specifically, the system control unit 119 searches the map data storage unit 115 on the basis of mobile data and navigation data received by the GPS receiving unit 111 to obtain predetermined data, and performs navigation processing including processing for search for a route to be traveled by the vehicle 101 on which the navigation apparatus 110 is mounted, and processing for guiding the vehicle 101 along the route. The system control unit 119 transmits a route search result, i.e., route data, to the control server apparatus 130 via the communication unit 120.

Detailed Description Text (34):
Further, the system control unit 119 is connected to a traveling mode changeover unit (not shown) which effects changeover between automatic traveling and normal-drive traveling controlled by the driver, and detects changeover between automatic traveling and normal-drive traveling. When the mode of traveling of the vehicle is changed from automatic traveling to normal-drive traveling or from normal-drive traveling to automatic traveling by the traveling mode changeover unit, the system control unit 119 transmits changeover data to the control server apparatus 130 via the communication unit 120 to inform the control server apparatus 130 that the traveling methods have been switched (condition data).

Detailed Description Text (35):

Specifically, in this embodiment, data on bodily conditions of the driver, e.g., condition of awaking and condition of sleep is detected when the traveling mode is changed from the automatic traveling mode to the normal driving mode. The traveling mode is changed after detecting such data.

Detailed Description Text (40):
The control server apparatus 130 is constituted by a wireless communication unit 131 which communicates with the navigation apparatus 110, a wired communication unit 132 which receives data on vehicles 101 etc. in the automatic traveling section, a database 133 in which data on automatic traveling of each vehicle 101 is stored, an automatic traveling section data recording unit 134 in which data about the automatic traveling section is recorded, and a system control unit 135 which controls traveling on each vehicle 101 in the automatic traveling route and performs centralized control on automatic traveling.

Detailed Description Text (41):
The control server apparatus 130 is served as the control apparatus in accordance with the present invention, and the wireless communication unit 131 is served as the receiving device and the route data acquisition device in accordance with the present invention. The system control unit 135 is served as the registration device, the changeover data acquisition device and the automatic guidance device in accordance with the present invention.

Detailed Description Text (43):
The wired communication unit 132 receives data on traveling of each vehicle 101 in the automatic traveling section. Therefore, the control server apparatus 130 can keep track of each travel-controlled vehicle 101 in the automatic traveling section on the basis of this data.

Detailed Description Text (44):
For example, the wired communication unit 132 obtains data on vehicles 101 received by a plurality of beacon receiving units (not shown) placed in the automatic traveling section. The wired communication unit 132 monitors the speeds of the vehicles, the distances between the vehicles, and control on confluence and divergence of the vehicles traveling in the automatic traveling section on the basis of the received data on each vehicle 101.

Detailed Description Text (45):
Control on traveling of each vehicle 101 (automatic guidance) is performed on the basis of an entry point and an exit point described below, which are computed by communication between the system control unit 135 and the automatic traveling apparatus (not shown) of the vehicle 101.

Detailed Description Text (47):
The automatic traveling section data recording unit 134 are recorded point data on an entry point and an exit point in the automatic traveling section (if a plurality of entry points and plurality of exit points exist, all the entry and exit points), and data on the automatic traveling section, i.e., data on confluence points, divergence points, drive stop areas (parking areas), drive rest areas (service areas), etc. According to an instruction from the system control unit 135, the database 133 is searched for predetermined data, which is output to the system control unit 135.

Detailed Description Text (48):
The system control unit 135 is supplied with identification data and route data of each vehicle 101 transmitted from the navigation apparatus 110. The system control unit 135 sets an entry point and an exit point in the automatic traveling section with respect to each vehicle 101 on the basis of the position data and the route data, computes a travel route along which the vehicle will travel automatically, forms data on each vehicle 101, and outputs the data to the database 133.

Detailed Description Text (49):
When each vehicle 101 reaches the entry point, the system control unit 135 obtains the identification data of the vehicle 101, collates the identification data with data on the vehicle 101 in the database 133, and controls automatic traveling of the vehicle 101 through the automatic traveling apparatus (not shown) mounted on the vehicle 101 on the basis of the data on the vehicle 101.

Detailed Description Text (50):
Also, the system control unit 135 receives data transmitted from the vehicle 101 for a notification that the vehicle has arrived at the entry point (automatic traveling start confirmation data) or a notification that the vehicle has arrived at the exit point (automatic traveling end confirmation data). The system control unit 135 starts or terminates processing relating to automatic traveling of the vehicle 101 when each vehicle 101 reaches the entry point or the exit point in the automatic traveling section.

Detailed Description Text (51):
Identification check terminals (not shown) for identifiing vehicles 101 are placed in the automatic traveling section. Each identification check terminal is used for transmitting and receiving identification data between the system control unit 135 and each vehicle 101. When one vehicle 101 reaches an entry point, the system control unit 135 receives automatic traveling start confirmation data transmitted from the vehicle 101, collates with the database the identification data of the vehicle 101 detected by the identification check terminal, and instructs each unit to start processing for automatic traveling if the corresponding data has already been registered in the database 133. If there is no corresponding data registered in the database 133 after collating the identification data of the detected vehicle 101 with the database 133, the system control unit 135 registers the identification data of the detected vehicle 101 in database 133 through the operating unit 116 of the navigation apparatus 110. In this embodiment, similar processing is performed at the exit point for changeover from automatic traveling to normal-drive traveling.

Detailed Description Text (57):
When a destination data is input through the operating unit 116 by a user, e.g., a driver, the system control unit 119 makes a route search (step S11), and the system control unit 119 starts route guidance (step S12). At this time, the system control unit 119 sets a point at which the distance between the position of the vehicle and the automatic traveling section is equal to a distance set in advance (hereinafter referred to as "registration data transmission point").

Detailed Description Text (61):
When the system control unit 135 receives route, data and identification data from one of vehicles 101, the vehicle 101 is registered in the control server apparatus 130 as a vehicle which will travel automatically on the basis of the identification data of the vehicle 101 (step S31).

Detailed Description Text (62):
The system control unit 135 then computes a route for traveling of the vehicle 101 in the automatic traveling section, including a point at which the vehicle 101 enters the automatic traveling section, a point at which the vehicle exits from the automatic traveling section, a confluence point, and divergence point, and stores these sorts of data in the database 133 along with the identification data of the vehicle 101 (route setting in the automatic traveling section (step S32)).

Detailed Description Text (63):
Subsequently, the system control unit 135 transmits data indicating that a registration of a route in the automatic traveling section has been completed (hereinafter referred to as section setting confirmation data) to the navigation

apparatus 110 through the wireless communication unit 131, and then waits for arrival of the vehicle 101 at the automatic traveling section (step S33).

Detailed Description Text (65):
First, the system control unit 119 makes a determination as to whether the section setting confirmation data transmitted from the control server apparatus 130 is received within a time period set in advance (step S15). If the section setting confirmation data is received within the time period set in advance, the system control unit 119 waits for arrival of the vehicle 101 at the automatic traveling route (step S16).

Detailed Description Text (67):
Subsequently, the system control unit 119 makes a determination in repeated cycles as to whether the vehicle 101 has reached the entry point in the automatic traveling section (step S17). When the system control unit 119 determines that the vehicle 101 has reached the automatic traveling section, it establishes a communication line to the control server apparatus 130 by the communication unit 120, transmits data indicating that the vehicle has reached the automatic traveling section, that is, a request for starting processing for automatic traveling (hereinafter referred to as "automatic traveling start request data") together with the identification data of the vehicle 101, and waits for reception of automatic traveling start confirmation data (step S18).

Detailed Description Text (68):
More specifically, the system control unit 119 makes a determination as to whether the vehicle 101 has reached the point according to the stored data at which the vehicle enters the automatic traveling section on the basis of the data on the entry point in the automatic traveling section obtained by the route search and stored in the navigation apparatus 110 and the position data of the vehicle 101 obtained from the wireless communication unit 131.

Detailed Description Text (69):
The arrangement may be such that identification check terminals (not shown) capable of obtaining vehicle data are placed at points at which entrance of vehicles 101 is possible, and arrival of vehicle 101 at each entry point is recognized when the identification check terminal detects the vehicle 101 registered in the control sever apparatus 130 set in advance as a vehicle which will travel automatically.

Detailed Description Text (71):
The system control unit 135 first makes a determination in repeated cycles as to whether the automatic traveling start request data and identification data transmitted from the navigation apparatus 110 have been received (step S34). If the automatic traveling start request data has been received, the system control unit 135 starts automatic traveling control and transmits automatic traveling start confirmation data to the navigation apparatus 110 (step S35).

Detailed Description Text (72):
If the system control unit 135 determines that the vehicle 101 is not registered in the automatic traveling section, it transmits a request for manual registration of the vehicle 101 to the navigation apparatus 110 (hereinafter referred to as "manual registration request data") (step S36) and terminates the operation.

Detailed Description Text (73):
Finally, in the navigation apparatus 110, the system control unit 119 makes a determination as to whether the automatic traveling start confirmation data or manual registration request data has been received within a time period set in advance. When the automatic traveling start confirmation data is received, the system control unit 119 performs control for making the automatic traveling apparatus (not shown) start automatic traveling, thereby starting automatic traveling (step S20). However, this control is started on condition that the

arrival of the vehicle 101 at the entry point is detected by the identification check terminal for recognizing each vehicle 101 at the entry point in the automatic traveling route.

Detailed Description Text (74):
If the automatic traveling start confirmation data is not received within the time period set in advance, or if the manual registration request data is not received, the system control unit 119 determines that registration processing has ended in failure and terminates the registration operation.

Detailed Description Text (75):
In this case, the system control unit 119 displays a predetermined notice on the display unit 117 or the like to request the user to register the vehicle 101 and to set an exit point etc. in the automatic travel control.

Detailed Description Text (79):
When the system control unit 135 in the control server apparatus 130 recognizes that the vehicle 101 has reached an exit point in the automatic traveling section based on a notice transmitted from the navigation apparatus 110 or by a predetermined method, e.g., detection by the identification check terminal (not shown) (step S51), it transmits data indicating that the vehicle has reached the exit point (hereinafter referred to as "exit confirmation data") to the navigation apparatus 110 and waits for receiving of changeover confirmation data or changeover non-confirmation data described below (step S52).

Detailed Description Text (81):
When the system control unit 119 receives the exit confirmation data (step S41), it provides a notice for requesting the driver to operate a certain device for switching from automatic traveling to manual traveling (i.e., normal-drive traveling) (step S42). For example, visual data such as shown in FIG. 6A is displayed on the display unit 117, or a speech notice is output from the speech guidance unit 118.

Detailed Description Text (86):
The vehicle 101 permitted to exit can perform normal-drive traveling. Therefore it exits from the automatic traveling section into a non-automatic traveling section and starts normal-drive traveling.

Detailed Description Text (87):
In the case where the system control unit 135 in the control server unit 130 has received changeover non-confirmation data, it determines that the driver is in such a condition that he or she cannot drive the vehicle 101, and controls each unit so that the vehicle 101 is made to turn aside out of the travel path into a parking area or the like (step S55), and terminates the operation.

Detailed Description Text (93):
When the route data transmitted from the navigation apparatus 110 is received (step S71), the system control unit 135 again computes a route for traveling of the vehicle 101 in the automatic traveling section, including a point at which the vehicle 101 exits from the automatic traveling section, a confluence point, and divergence point, and stores these sorts of data in the database 133 along with the identification data of the vehicle 101 ((step S72) route resetting in the automatic traveling section).

Detailed Description Text (94):
The system control unit 135 then transmits data indicating that a reregistration of a route in the automatic traveling section has been completed (hereinafter referred to as "resetting confirmation data") to the navigation apparatus 110 through the wireless communication unit 131 (step S73) and starts controlling automatic traveling of the vehicle, 101 (step S74) on the basis of the reset route.

Detailed Description Text (96):
According to this embodiment, in the case where at least part of an automatic traveling section is selected to be used as a traveling route as a result of a search for a traveling route to a destination which is to be reached by a vehicle 101, the navigation apparatus 110 registers the automatic traveling path to be used in the control server apparatus 130, and the control server apparatus 130 controls automatic traveling of the vehicle 101 along the automatic traveling path when the vehicle 101 travels in the automatic traveling section, thus performing automatic guidance of the vehicle.

Detailed Description Text (100):
Also, at least one of vehicle identification data, an entry point at which the vehicle enters the automatic traveling section, and an exit point at which the vehicle exits from the automatic traveling section can be registered as well as the automatic traveling section through which the vehicle 101 travels. Therefore entry into the automatic traveling section and exit from the automatic traveling section can be controlled with reliability. Since each vehicle 101 can be easily identified based on the identification data, automatic traveling control can be correctly performed with respect to each vehicle 101, thus enabling management on the automatic traveling section to be performed smoothly.

Detailed Description Text (101):
When switching of the traveling mode from automatic traveling to normal-drive traveling or from normal-drive traveling to automatic traveling at an entry point or an exit point in the automatic traveling section is detected, starting and termination of automatic traveling of the vehicle can be controlled. Therefore, if switching of the traveling mode is detected when the vehicle 101 enters the automatic traveling section or exits from the automatic traveling section, automatic traveling can be started or terminated. If the traveling mode is not switched to normal-drive traveling after the completion of traveling through the automatic traveling section, the vehicle is not allowed to enter a normal-drive traveling path but made to turn aside into a parking area or the like. Thus, safety of the vehicle traveling in both automatic and non-automatic traveling sections can be ensured without requiring any troublesome operation.

Detailed Description Text (102):
A conventional automatic operation control apparatus 10 shown in FIG. 9 is comprised a position detecting device 11 for detecting the position of a traveling vehicle, an operation mode changeover and notifying device 12 which effects changeover between an automatic driving mode and a normal driving mode (in which normal-drive traveling controlled by a driver is performed), an automatic driving controller 13 which controls driving of the vehicle, an actuator 14 which controls the traveling speed of the vehicle and the steering angle, and a detection device 15 which detects a steering operation performed by the driver at the time of changeover of the traveling mode from the automatic-drive traveling mode to the normal-drive traveling mode.

Detailed Description Text (103):
This conventional automatic operation control apparatus 10 is arranged to control traveling of the vehicle on the basis of the result of detection performed by the detection device 15. When the steering operation is detected at the time of changeover from automatic-drive traveling to normal-drive traveling, it is recognized that the driver is preparing for manual driving. That is, this result of detection of the steering operation indicates that the steering operation for steering the vehicle to the target road is being performed. In this situation, therefore, automatic driving control is not required and the operation mode can be changed from automatic-drive traveling to normal-drive traveling.

Detailed Description Text (104):

The conventional automatic operation control apparatus 10, however, requires a driver's operation for changing the vehicle traveling mode from the automatic-drive traveling mode to the normal-drive traveling mode during automatic-drive traveling. If the driver misses a point at which changeover from automatic-drive traveling to normal-drive traveling should be made, there is a possibility that the vehicle cannot travel the route on which the vehicle should travel.

Detailed Description Text (105):
Also, it is thought that in the case where a driver previously sets points at which the vehicle traveling mode should be changed from automatic-drive traveling to normal-drive traveling, troublesome operations for setting of an exit point etc. are required.

Detailed Description Text (106):
Consequently, the conventional automatic operation control apparatus is not capable of easily registering an automatic traveling section in comparison with this embodiment of the present invention.

Detailed Description Text (110):
In this embodiment, a route search for a vehicle is performed by the navigation apparatus mounted on the vehicle, and a registration of the vehicle with respect to an automatic traveling section and cancellation of the registration are made by performing communication with the control server apparatus. However, the arrangement may alternatively be such that an data server apparatus is fixedly installed in a place freely selected; a communication terminal device is mounted on a vehicle; communication is performed between the data server apparatus and the communication terminal device to enable navigation of the vehicle; and identification data and route data of the vehicle are transmitted to a control server apparatus.

Detailed Description Text (111):
In such a case, an automatic guidance system 200 is comprised, as shown in FIG. 8, an data server apparatus 210, a communication terminal device 220 which communicates with the data server apparatus 210 through a mobile communication network 102, and a control server apparatus 130. The control server apparatus 130 communicates with the data server apparatus 210 through a communication line such as a public telephone network line. The communication terminal device 220 obtains position data and destination data for traveling of a vehicle 101 on which the communication terminal device 220 is mounted, and transmits the data to the data server apparatus 210. The data server apparatus 210 receives route data and identification data obtained by the communication terminal device, performs route search processing, and transmits necessary data to the control server apparatus 130.

Detailed Description Text (112):
In this embodiment, the automatic guidance system is comprised the control server apparatus and the navigation apparatus or the control server apparatus, the data server apparatus and the communication terminal device. One of them is comprised by the above-described components. Each of the system control units 119 and 135 in the navigation apparatus and the data server apparatus or in the data server apparatus, the communication terminal device and the control server apparatus may be provided with a computer and a recording medium such as a hard disk. Programs for performing the above-described processings corresponding to the units of the data server apparatus and the navigation apparatus or the data server apparatus, the control server apparatus, and the communication terminal device may be stored on the recording mediums, and the programs may be read to the computers to enable the computers to respectively operate the data server apparatus and the navigation apparatus or the data server apparatus, the communication terminal device and the control server apparatus.

Detailed Description Text (113):
In this case, each of the system control units 119 and 135 in the data server apparatus and the navigation apparatus or the data server apparatus, the communication terminal device and the control server apparatus is connected to the control units of the other apparatus. Each of their computers which is operated in a linked relationship performs one of the above-described registration processing, cancellation processing and reregistration processing. In this case, each of the system control units 119 and 135 is served as one of the registration device, acquisition device, route search device, re-search device, changeover data acquisition device, receiving device, route data acquisition device, and automatic guidance device in accordance with the present invention.

Current US Cross Reference Classification (2):
701/208

CLAIMS:

1. An automatic vehicle guidance system for guiding a vehicle which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path, said automatic vehicle guidance system comprising: a control device for managing said automatic traveling section, and controlling the vehicle traveling in said automatic traveling section; an acquisition device for obtaining present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search device for making a search for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; and a registration device for registering said automatic traveling path which is included in the travel route if at least part of said automatic traveling section is included in the travel route as a result of the route search, wherein said control device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

4. The automatic vehicle guidance system according to claim 3, in a case where at least one of the entry point data and the exit point data is registered by said registration device, further comprising: a receiving device for receiving arrival data indicating that the vehicle reaches at least one of the entry point and the exit point, wherein said control device controls at least one of starting and termination of automatic traveling of the vehicle on the basis of the arrival data.

5. The automatic vehicle guidance system according to claim 3, in a case where at least one of the entry point data and the exit point data is registered by said registration device, further comprising: a detection device for detecting at least one of changeover of the traveling mode from the automatic traveling to normal-drive traveling based on manual operations, and changeover of the traveling mode from the normal-drive traveling to the automatic traveling, wherein said control device controls at least one of starting and termination of automatic traveling of the vehicle when said detection device detects at least one of changeover of the traveling mode at the entry point, and changeover of the traveling mode at the exit point.

6. The automatic vehicle guidance system according to claim 5, wherein: said detection device detects changeover of the traveling mode based on condition data of the driver who is operating the vehicle.

7. The automatic vehicle guidance system according to claim 6, wherein: the condition data has bodily data indicating condition which is included at least one of an awake condition and an asleep condition of driver, and said detection device detects changeover of the traveling mode based on the bodily data.

10. The automatic vehicle guidance system according to claim 9, wherein: said navigation system comprises an data server device fixedly installed, and a communication terminal device mounted on the vehicle and communicating with said data server device through a mobile communication network, said communication terminal device and said data server device communicate with each other to perform navigation of the vehicle, said data server device and said registration device communicate with each other to register said automatic traveling path which is included in the travel route as a result of the route search, and said control device performs automatic guidance of the vehicle traveling in said automatic traveling section.

11. A control apparatus for an automatic vehicle guidance system for guiding a vehicle, which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path, said control apparatus comprising: a control device for managing said automatic traveling section and controlling the vehicle traveling in said automatic traveling section; a route data acquisition device for obtaining route data indicating a travel route to destination to be reached by the vehicle as a result of route search based on present position data of the vehicle, and destination data indicating a destination to be reached by the vehicle; and a registration device for registering said automatic traveling path which is included in the travel route if at least part of said automatic traveling section is included in the travel route as a result of the route search, wherein said control device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

12. The control apparatus according to claim 11, wherein: if a travel route to the destination is set by the re-search while the vehicle is traveling in said automatic traveling section, said registration device reregisters said automatic traveling path on the basis of the travel route set by the re-search.

13. The control apparatus according to claim 11, wherein: when said registration device registers said automatic traveling path, it registers at least one of the identification data of the vehicle, entry point data indicating an entry point at which the vehicle enters said automatic traveling section, and exit point data indicating an exit point at which the vehicle exits from said automatic traveling section.

14. The control apparatus according to claim 13, in a case where at least one of the entry point data and the exit point data is registered by said registration device, further comprising: a receiving device for receiving arrival data indicating that the vehicle reaches at least one of the entry point and the exit point, wherein said control device controls at least one of starting and termination of automatic traveling of the vehicle on the basis of the arrival data.

15. The control apparatus according to claim 13, in a case where at least one of the entry point data and the exit point data is registered by said registration device, further comprising: a changeover data acquisition device obtains changeover data which includes at least one of data indicating changeover of the traveling mode from the automatic traveling to normal-drive traveling based on manual operations in the vehicle, and data indicating changeover of the traveling mode from the normal-drive traveling to the automatic traveling in the vehicle, wherein said control device controls at least one of starting and termination of automatic traveling of the vehicle when said changeover data acquisition device obtains the changeover data.

17. An automatic vehicle guidance method in which automatic guidance of a vehicle is performed by controlling traveling of the vehicle in an automatic traveling

section which is a travel path on which the vehicle travels in an automatic traveling manner without being operated by a driver, comprising: an acquisition process of obtaining present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search process of making a search for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; a registration process of registering said automatic traveling path which is included in the travel route if at least part of said automatic traveling section is included in the travel route as a result of the route search; and an automatic guidance process of controlling automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

21. A data recorded medium wherein an automatic vehicle guidance program is recorded so as to be read by a computer, the computer included in an automatic vehicle guidance system for guiding a vehicle which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path, the automatic vehicle guidance program causing the computer to function as: a control device manages said automatic traveling section and controls the vehicle traveling in said automatic traveling section; an acquisition device obtains present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search device makes a search for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; and a registration device registers said automatic traveling path which is included in the travel route if at least part of said automatic traveling section is included in the travel route as a result of the route search; and an automatic guidance device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

L16: Entry 1 of 1 File: USPT Jul 8, 2003

DOCUMENT-IDENTIFIER: US 6591172 B2
TITLE: AUTOMATIC VEHICLE GUIDANCE SYSTEM, CONTROL APPARATUS IN AUTOMATIC VEHICLE GUIDANCE SYSTEM, AUTOMATIC VEHICLE GUIDANCE METHOD, AND COMPUTER-READABLE DATA RECORDED MEDIUM IN WHICH AUTOMATIC VEHICLE GUIDANCE SYSTEM PROGRAM IS RECORDED

Application Filing Date (1):
20021025

Brief Summary Text (3):
The present invention relates to techniques for automatic-drive traveling of a vehicle in techniques relating to intelligent transport systems (ITS) and, more particularly, to a technique for registering an automatic traveling route for a vehicle by using a navigation system.

Brief Summary Text (5):
In recent years, techniques have been realized which relate to intelligent transport systems (ITS) in which automatic toll payment and collection operations (in an automatic toll collection system) are performed by transmitting and receiving data between a vehicle and apparatuses installed on roads by mobile communication system. Studies of other techniques relating to ITS, i.e., techniques for support to careful driving, optimization of traffic control, etc. have also been advanced. In particular, studies of a kind of automatic guidance system relating to automatic traveling are being advanced by experiments based on traveling of actual vehicles. In the automatic guidance system, a driver does not perform driving operations but traveling of a vehicle such as a automobile in which the driver is riding is controlled in guiding the traveling vehicle.

Brief Summary Text (6):
For realization of such an automatic guidance system, building of infrastructures including roads is required as well as providing special-purpose equipment in vehicles. Possible forms of roads on which automatic traveling is performed include one in which particular travel paths are set as automatic traveling sections in which only vehicles capable of complete automatic traveling can be made to travel, and one in which an automatic traveling section and a non-automatic traveling section in which vehicles travel ordinarily by being operated by drivers are set in parallel with each other. That is, even if an automatic guidance system is realized, automatic traveling of all vehicles in operation is not possible at an initial stage of implementation of the system or automatic traveling cannot be performed on some roads, and conventional sections in which vehicles are manually driven by drivers and vehicles driven by drivers in the conventional manner coexist. For this reason, the above-described forms of roads are conceivable.

Brief Summary Text (8):
The conventional automatic operation control apparatus, however, requires a driver's operation for changing the vehicle traveling mode from the automatic-drive traveling mode to the normal-drive traveling mode during automatic-drive traveling. If the driver misses a point at which changeover from automatic-drive traveling to normal-drive traveling should be made, there is a possibility that the vehicle

cannot travel the route on which the vehicle should travel.

Brief Summary Text (9):
Also, it is thought that in the case where a driver previously sets points at which the vehicle traveling mode should be changed from automatic-drive traveling to normal-drive traveling, troublesome operations for setting of an exit point etc. are required.

Brief Summary Text (12):
The above object of present invention can be achieved by an automatic vehicle guidance system of the present invention. The automatic vehicle system for guiding a vehicle which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path is provided with: a control device for managing the automatic traveling section, and controlling the vehicle traveling in the automatic traveling section; an acquisition device for obtaining present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search device for making a search for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; and a registration device for registering the automatic traveling path which is included in the travel route if at least part of the automatic traveling section is included in the travel route as a result of the route search, and the control device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

Brief Summary Text (26):
In one aspect of the present invention, in a case where at least one of the entry point data and the exit point data is registered by the registration device the automatic vehicle guidance system is further provided with: a detection device for detecting at least one of changeover of the traveling mode from the automatic traveling to normal-drive traveling based on manual operations, and changeover of the traveling mode from the normal-drive traveling to the automatic traveling, and the control device controls at least one of starting and termination of automatic traveling of the vehicle when the detection device detects at least one of changeover of the traveling mode at the entry point, and changeover of the traveling mode at the exit point.

Brief Summary Text (28):
Accordingly, if changeover of the traveling mode is detected when the vehicle enters the automatic traveling section or exits from the automatic traveling section, automatic traveling can be started or terminated. For example, if the traveling mode is not changed to normal-drive traveling after the completion of traveling through the automatic traveling section, the vehicle is not allowed to enter a normal-drive traveling path but made to turn aside into a parking area or the like. Thus, safety of the vehicle traveling in both automatic and non-automatic traveling sections can be ensured without requiring any troublesome operation.

Brief Summary Text (29):
In one aspect of the present invention, the automatic vehicle guidance system is further provided with: the detection device detects changeover of the traveling mode based on condition data of the driver who is operating the vehicle.

Brief Summary Text (30):
According to the present invention, it is possible to prevent the vehicle from exiting from the automatic traveling section into a non-automatic traveling section when the driver is unable to operate the vehicle, thus ensuring safety of the vehicle traveling in both automatic and non-automatic traveling sections.

Brief Summary Text (31):

In one aspect of the present invention, the automatic vehicle guidance system is further provided with: the condition data has bodily data indicating condition which is included at least one of an awake condition and an asleep condition of driver, and the detection device detects changeover of the traveling mode based on the bodily data.

Brief Summary Text (32):
According to the present invention, it is possible to prevent the vehicle from exiting from the automatic traveling section into a non-automatic traveling section when normal driving is not possible, thus ensuring safety of the vehicle traveling in both automatic and non-automatic traveling sections.

Brief Summary Text (39):
The above object of present invention can be achieved by a control apparatus for an automatic vehicle guidance system for guiding a vehicle which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path of the present invention. The control apparatus is provided with: a control device for managing the automatic traveling section and controlling the vehicle traveling in the automatic traveling section; a route data acquisition device for obtaining route data indicating a travel route to destination to be reached by the vehicle as a result of route search based on present position data of the vehicle, and destination data indicating a destination to be reached by the vehicle; and a registration device for registering the automatic traveling path which is included in the travel route if at least part of the automatic traveling section is included in the travel route as a result of the route search, and the control device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

Brief Summary Text (53):
In one aspect of the present invention, in a case where at least one of the entry point data and the exit point data is registered by the registration device, the control apparatus is further provided with: a changeover data acquisition device obtains changeover data which includes at least one of data indicating changeover of the traveling mode from the automatic traveling to normal-drive traveling based on manual operations in the vehicle, and data indicating changeover of the traveling mode from the normal-drive traveling to the automatic traveling in the vehicle, the control device controls at least one of starting and termination of automatic traveling of the vehicle when the changeover data acquisition device obtains the changeover data.

Brief Summary Text (55):
Accordingly, if changeover of the traveling mode is detected when the vehicle enters the automatic traveling section or exits from the automatic traveling section, automatic traveling can be started or terminated. For example, if the traveling mode is not changed to normal-drive traveling after the completion of traveling through the automatic traveling section, the vehicle is not allowed to enter a normal-drive traveling path but made to turn aside into a parking area or the like. Thus, safety of the vehicle traveling in both automatic and non-automatic traveling sections can be ensured without requiring any troublesome operation.

Brief Summary Text (58):
The above object of present invention can be achieved by an automatic vehicle guidance method of the present invention. The automatic vehicle method, in which automatic guidance of a vehicle is performed by controlling traveling of the vehicle in an automatic traveling section which is a travel path on which the vehicle travels in an automatic traveling manner without being operated by a driver, is provided with: an acquisition process of obtaining present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search process of making a search

for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; a registration process of registering the automatic traveling path which is included in the travel route if at least part of the automatic traveling section is included in the travel route as a result of the route search; and an automatic guidance process of controlling automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

Brief Summary Text (71):
The above object of present invention can be achieved by a data recorded medium of the present inversion automatic vehicle guidance system of the present invention wherein an automatic vehicle guidance program is recorded so as to be read by a computer, the computer included in an automatic vehicle guidance system for guiding a vehicle which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path, the automatic vehicle guidance program causing the computer to function as: a control device manages the automatic traveling section and controls the vehicle traveling in the automatic traveling section; an acquisition device obtains present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search device makes a search for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; and a registration device registers the automatic traveling path which is included in the travel route if at least part of the automatic traveling section is included in the travel route as a result of the route search; and an automatic guidance device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

Drawing Description Text (7):
FIGS. 6A, 6B, and 6C are diagrams each showing an example of a changeover notice displayed on a display unit at the time of changeover from automatic traveling to normal-drive traveling in the embodiment of the present invention;

Detailed Description Text (7):
As shown in FIG. 1, the automatic guidance system 100 of this embodiment is constituted by a navigation apparatus 110 mounted on a vehicle, 101, and a control server apparatus 130 provided as a stationary unit in an automatic travel control center for control over an automatic traveling section in which traveling of a vehicle is controlled with no driver's operation. The control server apparatus 130 and the navigation apparatus 110 have a communication line established therebetween through a mobile communication network 102 which includes a public telephone network line or an Internet.

Detailed Description Text (18):
As shown in FIG. 2, the navigation apparatus 110 is constituted by a GPS receiving unit 111 which is connected to an antenna AT, and which receives GPS data, a speed/acceleration sensor unit 112 which detects the speed of traveling and acceleration of the vehicle, an azimuth sensor section 113 that senses the azimuth of the vehicle, a VICS data receiving unit 114 which receives VICS data from the vehicle information and communication system (VICS), a map data storage unit 115 in which map data is stored, an operating unit 116, a display unit 117 which displays map data and the position of the vehicle, a speech guidance unit 118 which outputs speeches for guidance, a system control unit 119 for overall control of the system, and a communication unit 120 which is connected to the antenna AT, and which performs communication with the control server apparatus 130.

Detailed Description Text (25):
The map data storage unit 115 stores, in a readable state, map data such as road maps and other sorts of data necessary for travel guidance. For example, the map data storage unit 115 is constituted by a DVD drive which reads out map data or the

like from a DVD-read only memory (DVD-ROM) on which data necessary for travel guidance including the map data is stored, or a hard disk having map data etc. stored thereon.

Detailed Description Text (27):
The display unit 117 displays map data output from the map data storage unit 115, and data on various conditions including those relating to travel guidance performed by the navigation apparatus 110, and data on a destination.

Detailed Description Text (28):
The speech guidance unit 118 outputs, in speech form, travel route guidance data. The travel route guidance data include data on the vehicle traveling direction from the next intersection, and data to be notified directly to the driver in guidance (congestion data, road closure data, etc.).

Detailed Description Text (30):
The system control unit 119 controls display unit 117 etc. so that the above-described travel route guidance data is displayed on display unit 117 in a map on which the present position of the vehicle is shown in a peripheral area on the basis of traveling data (vehicle position and speed data) obtained by a position computation unit (not shown). The system control unit 119 also controls the speech guidance unit 118 etc. so that corresponding travel route guidance data or the like is output as a speech from the speech guidance unit 118.

Detailed Description Text (32):
More specifically, the system control unit 119 searches the map data storage unit 115 on the basis of mobile data and navigation data received by the GPS receiving unit 111 to obtain predetermined data, and performs navigation processing including processing for search for a route to be traveled by the vehicle 101 on which the navigation apparatus 110 is mounted, and processing for guiding the vehicle 101 along the route. The system control unit 119 transmits a route search result, i.e., route data, to the control server apparatus 130 via the communication unit 120.

Detailed Description Text (34):
Further, the system control unit 119 is connected to a traveling mode changeover unit (not shown) which effects changeover between automatic traveling and normal-drive traveling controlled by the driver, and detects changeover between automatic traveling and normal-drive traveling. When the mode of traveling of the vehicle is changed from automatic traveling to normal-drive traveling or from normal-drive traveling to automatic traveling by the traveling mode changeover unit, the system control unit 119 transmits changeover data to the control server apparatus 130 via the communication unit 120 to inform the control server apparatus 130 that the traveling methods have been switched (condition data).

Detailed Description Text (35):
Specifically, in this embodiment, data on bodily conditions of the driver, e.g., condition of awaking and condition of sleep is detected when the traveling mode is changed from the automatic traveling mode to the normal driving mode. The traveling mode is changed after detecting such data.

Detailed Description Text (47):
The automatic traveling section data recording unit 134 are recorded point data on an entry point and an exit point in the automatic traveling section (if a plurality of entry points and plurality of exit points exist, all the entry and exit points), and data on the automatic traveling section, i.e., data on confluence points, divergence points, drive stop areas (parking areas), drive rest areas (service areas), etc. According to an instruction from the system control unit 135, the database 133 is searched for predetermined data, which is output to the system control unit 135.

Detailed Description Text (51):
Identification check terminals (not shown) for identifiing vehicles 101 are placed in the automatic traveling section. Each identification check terminal is used for transmitting and receiving identification data between the system control unit 135 and each vehicle 101. When one vehicle 101 reaches an entry point, the system control unit 135 receives automatic traveling start confirmation data transmitted from the vehicle 101, collates with the database the identification data of the vehicle 101 detected by the identification check terminal, and instructs each unit to start processing for automatic traveling if the corresponding data has already been registered in the database 133. If there is no corresponding data registered in the database 133 after collating the identification data of the detected vehicle 101 with the database 133, the system control unit 135 registers the identification data of the detected vehicle 101 in database 133 through the operating unit 116 of the navigation apparatus 110. In this embodiment, similar processing is performed at the exit point for changeover from automatic traveling to normal-drive traveling.

Detailed Description Text (81):
When the system control unit 119 receives the exit confirmation data (step S41), it provides a notice for requesting the driver to operate a certain device for switching from automatic traveling to manual traveling (i.e., normal-drive traveling) (step S42). For example, visual data such as shown in FIG. 6A is displayed on the display unit 117, or a speech notice is output from the speech guidance unit 118.

Detailed Description Text (86):
The vehicle 101 permitted to exit can perform normal-drive traveling. Therefore it exits from the automatic traveling section into a non-automatic traveling section and starts normal-drive traveling.

Detailed Description Text (87):
In the case where the system control unit 135 in the control server unit 130 has received changeover non-confirmation data, it determines that the driver is in such a condition that he or she cannot drive the vehicle 101, and controls each unit so that the vehicle 101 is made to turn aside out of the travel path into a parking area or the like (step S55), and terminates the operation.

Detailed Description Text (101):
When switching of the traveling mode from automatic traveling to normal-drive traveling or from normal-drive traveling to automatic traveling at an entry point or an exit point in the automatic traveling section is detected, starting and termination of automatic traveling of the vehicle can be controlled. Therefore, if switching of the traveling mode is detected when the vehicle 101 enters the automatic traveling section or exits from the automatic traveling section, automatic traveling can be started or terminated. If the traveling mode is not switched to normal-drive traveling after the completion of traveling through the automatic traveling section, the vehicle is not allowed to enter a normal-drive traveling path but made to turn aside into a parking area or the like. Thus, safety of the vehicle traveling in both automatic and non-automatic traveling sections can be ensured without requiring any troublesome operation.

Detailed Description Text (102):
A conventional automatic operation control apparatus 10 shown in FIG. 9 is comprised a position detecting device 11 for detecting the position of a traveling vehicle, an operation mode changeover and notifying device 12 which effects changeover between an automatic driving mode and a normal driving mode (in which normal-drive traveling controlled by a driver is performed), an automatic driving controller 13 which controls driving of the vehicle, an actuator 14 which controls the traveling speed of the vehicle and the steering angle, and a detection device 15 which detects a steering operation performed by the driver at the time of

changeover of the traveling mode from the automatic-drive traveling mode to the normal-drive traveling mode.

Detailed Description Text (103):
This conventional automatic operation control apparatus 10 is arranged to control traveling of the vehicle on the basis of the result of detection performed by the detection device 15. When the steering operation is detected at the time of changeover from automatic-drive traveling to normal-drive traveling, it is recognized that the driver is preparing for manual driving. That is, this result of detection of the steering operation indicates that the steering operation for steering the vehicle to the target road is being performed. In this situation, therefore, automatic driving control is not required and the operation mode can be changed from automatic-drive traveling to normal-drive traveling.

Detailed Description Text (104):
The conventional automatic operation control apparatus 10, however, requires a driver's operation for changing the vehicle traveling mode from the automatic-drive traveling mode to the normal-drive traveling mode during automatic-drive traveling. If the driver misses a point at which changeover from automatic-drive traveling to normal-drive traveling should be made, there is a possibility that the vehicle cannot travel the route on which the vehicle should travel.

Detailed Description Text (105):
Also, it is thought that in the case where a driver previously sets points at which the vehicle traveling mode should be changed from automatic-drive traveling to normal-drive traveling, troublesome operations for setting of an exit point etc. are required.

Current US Cross Reference Classification (2):
701/208

CLAIMS:

1. An automatic vehicle guidance system for guiding a vehicle which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path, said automatic vehicle guidance system comprising: a control device for managing said automatic traveling section, and controlling the vehicle traveling in said automatic traveling section; an acquisition device for obtaining present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search device for making a search for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; and a registration device for registering said automatic traveling path which is included in the travel route if at least part of said automatic traveling section is included in the travel route as a result of the route search, wherein said control device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

5. The automatic vehicle guidance system according to claim 3, in a case where at least one of the entry point data and the exit point data is registered by said registration device, further comprising: a detection device for detecting at least one of changeover of the traveling mode from the automatic traveling to normal-drive traveling based on manual operations, and changeover of the traveling mode from the normal-drive traveling to the automatic traveling, wherein said control device controls at least one of starting and termination of automatic traveling of the vehicle when said detection device detects at least one of changeover of the traveling mode at the entry point, and changeover of the traveling mode at the exit point.

6. The automatic vehicle guidance system according to claim 5, wherein: said detection device detects changeover of the traveling mode based on condition data of the driver who is operating the vehicle.

7. The automatic vehicle guidance system according to claim 6, wherein: the condition data has bodily data indicating condition which is included at least one of an awake condition and an asleep condition of driver, and said detection device detects changeover of the traveling mode based on the bodily data.

11. A control apparatus for an automatic vehicle guidance system for guiding a vehicle, which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path, said control apparatus comprising: a control device for managing said automatic traveling section and controlling the vehicle traveling in said automatic traveling section; a route data acquisition device for obtaining route data indicating a travel route to destination to be reached by the vehicle as a result of route search based on present position data of the vehicle, and destination data indicating a destination to be reached by the vehicle; and a registration device for registering said automatic traveling path which is included in the travel route if at least part of said automatic traveling section is included in the travel route as a result of the route search, wherein said control device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

15. The control apparatus according to claim 13, in a case where at least one of the entry point data and the exit point data is registered by said registration device, further comprising: a changeover data acquisition device obtains changeover data which includes at least one of data indicating changeover of the traveling mode from the automatic traveling to normal-drive traveling based on manual operations in the vehicle, and data indicating changeover of the traveling mode from the normal-drive traveling to the automatic traveling in the vehicle, wherein said control device controls at least one of starting and termination of automatic traveling of the vehicle when said changeover data acquisition device obtains the changeover data.

17. An automatic vehicle guidance method in which automatic guidance of a vehicle is performed by controlling traveling of the vehicle in an automatic traveling section which is a travel path on which the vehicle travels in an automatic traveling manner without being operated by a driver, comprising: an acquisition process of obtaining present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search process of making a search for a travel route to the destination on the basis of the present position data and the destination data relating to the vehicle; a registration process of registering said automatic traveling path which is included in the travel route if at least part of said automatic traveling section is included in the travel route as a result of the route search; and an automatic guidance process of controlling automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

21. A data recorded medium wherein an automatic vehicle guidance program is recorded so as to be read by a computer, the computer included in an automatic vehicle guidance system for guiding a vehicle which travels in an automatic traveling manner without being operated by a driver in an automatic traveling section which is an automatic traveling path, the automatic vehicle guidance program causing the computer to function as: a control device manages said automatic traveling section and controls the vehicle traveling in said automatic traveling section; an acquisition device obtains present position data indicating the present position of the vehicle, and destination data indicating a destination to be reached by the vehicle; a route search device makes a search for a travel

route to the destination on the basis of the present position data and the destination data relating to the vehicle; and a registration device registers said automatic traveling path which is included in the travel route if at least part of said automatic traveling section is included in the travel route as a result of the route search; and an automatic guidance device controls automatic traveling of the vehicle along the registered automatic traveling path to perform automatic guidance of the vehicle.

Previous Doc Next Doc Go to Doc#

IDS 10/716741

L6: Entry 2 of 2 File: USPT Nov 21, 2000

US-PAT-NO: 6151539
DOCUMENT-IDENTIFIER: US 6151539 A

TITLE: Autonomous vehicle arrangement and method for controlling an autonomous vehicle

DATE-ISSUED: November 21, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bergholz; Ralf	Braunschweig			DE
Timm; Klaus	Wentorf			DE
Weisser; Hubert	Lehre			DE

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Volkswagen AG	Wolfsburg			DE	03

APPL-NO: 09/ 185291 [PALM]
DATE FILED: November 3, 1998

FOREIGN-APPL-PRIORITY-DATA:

COUNTRY	APPL-NO	APPL-DATE
DE	197 48 405	November 3, 1997

INT-CL: [07] G01 C 22/00, G05 D 1/00

US-CL-ISSUED: 701/25; 701/300, 701/301, 701/200, 701/201, 701/96, 340/435, 340/904
US-CL-CURRENT: 701/25; 340/435, 340/904, 701/200, 701/201, 701/300, 701/301, 701/96

FIELD-OF-SEARCH: 701/25, 701/200, 701/96, 701/117, 701/301, 701/201, 701/300, 340/907, 340/901, 340/902, 340/903, 340/904, 340/905, 340/425.5, 340/435

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
5229941	July 1993	Hattori	364/424
5396426	March 1995	Hibino et al.	701/96

☐	5467284	November 1995	Yoshioka et al.	701/301
☐	5594413	January 1997	Cho et al.	340/903
☐	5610815	March 1997	Gudat et al.	364/424
☐	5684696	November 1997	Rao et al.	701/25
☐	5732385	March 1998	Nakayama et al.	701/201
☐	5835028	November 1998	Bender et al.	340/937
☐	5944768	August 1999	Ito et al.	701/200
☐	5964822	October 1999	Alland et al.	701/301
☐	5999092	December 1999	Smith et al.	340/436
☐	6026346	February 2000	Ohashi et al.	701/210
☐	6060989	May 2000	Gehlot	340/576

FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US-CL
0679975	November 1995	EP	
0679976	November 1995	EP	
9613024	May 1996	WO	

OTHER PUBLICATIONS

"Implementation of Active Safety Systems to Avoid Frontal Collisions" by A. Saroldi; pp. 31-36.
"Lateral Support for Collision Avoidance" by Antonello et al; pp. 19-30.
"ProLab2: An Intelligent Onboard System for Driving Assistance" by Rombaut et al; pp. 31-47.
"Towards Autonomous Cruising on Highways" by Okuno et al; pp. 7-16.

ART-UNIT: 361

PRIMARY-EXAMINER: Cuchlinski, Jr.; William A.

ASSISTANT-EXAMINER: Hernandez; Olga

ATTY-AGENT-FIRM: Baker Botts L.L.P.

ABSTRACT:

An autonomous vehicle and method for controlling it includes an input unit to receive one or more travel orders, a route planning unit containing at least one position finding device and digital street map, a vehicle path generating a unit, an array of sensors including at least one range sensor for detecting objects and at least one range sensor for detecting the condition features of the route, a collision avoidance unit, a vehicle condition data recognition unit, a vehicle control unit and a unit for controlling the vehicle actuator system based on the signals generated by the vehicle control unit, wherein the array of sensors includes at least two essentially horizontally directed range sensors at the front of the vehicle, at least one range sensor at the rear area of the vehicle, at least one trackable range sensor on the roof of the vehicle and directed at the roadway, ultrasonic sensors and/or microwave radar sensors arranged on each side of the

vehicle, and at least one camera located in each of the front and rear areas of the vehicle.

31 Claims, 9 Drawing figures

Previous Doc Next Doc Go to Doc#

US006151539A

United States Patent [19]

Bergholz et al.

[11] Patent Number: 6,151,539

[45] Date of Patent: Nov. 21, 2000

[54] AUTONOMOUS VEHICLE ARRANGEMENT AND METHOD FOR CONTROLLING AN AUTONOMOUS VEHICLE

[75] Inventors: **Ralf Bergholz**, Braunschweig; **Klaus Timm**, Wentorf; **Hubert Weisser**, Lehre, all of Germany

[73] Assignee: **Volkswagen AG**, Wolfsburg, Germany

[21] Appl. No.: **09/185,291**

[22] Filed: **Nov. 3, 1998**

[30] **Foreign Application Priority Data**

Nov. 3, 1997 [DE] Germany 197 48 405

[51] **Int. Cl.**[7] **G01C 22/00**; G05D 1/00

[52] **U.S. Cl.** **701/25**; 701/300; 701/301; 701/200; 701/201; 701/96; 340/435; 340/904

[58] **Field of Search** 701/25, 200, 96, 701/117, 301, 201, 300; 340/907, 901, 902, 903, 904, 905, 425.5, 435

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,229,941	7/1993	Hattori	364/424
5,396,426	3/1995	Hibino et al.	701/96
5,467,284	11/1995	Yoshioka et al.	701/301
5,594,413	1/1997	Cho et al.	340/903
5,610,815	3/1997	Gudat et al.	364/424
5,684,696	11/1997	Rao et al.	701/25
5,732,385	3/1998	Nakayama et al.	701/201
5,835,028	11/1998	Bender et al.	340/937
5,944,768	8/1999	Ito et al.	701/200
5,964,822	10/1999	Alland et al.	701/301
5,999,092	12/1999	Smith et al.	340/436
6,026,346	2/2000	Ohashi et al.	701/210
6,060,989	5/2000	Gehlot	340/576

FOREIGN PATENT DOCUMENTS

0679975	11/1995	European Pat. Off. .
0679976	11/1995	European Pat. Off. .
9613024	5/1996	WIPO .

OTHER PUBLICATIONS

"Implementation of Active Safety Systems to Avoid Frontal Collisions" by A. Saroldi; pp. 31–36.

"Lateral Support for Collision Avoidance" by Antonello et al; pp. 19–30.

"ProLab2: An Intelligent Onboard System for Driving Assistance" by Rombaut et al; pp. 31–47.

"Towards Autonomous Cruising on Highways" by Okuno et al; pp. 7–16.

Primary Examiner—William A. Cuchlinski, Jr.
Assistant Examiner—Olga Hernandez
Attorney, Agent, or Firm—Baker Botts L.L.P.

[57] **ABSTRACT**

An autonomous vehicle and method for controlling it includes an input unit to receive one or more travel orders, a route planning unit containing at least one position finding device and digital street map, a vehicle path generating a unit, an array of sensors including at least one range sensor for detecting objects and at least one range sensor for detecting the condition features of the route, a collision avoidance unit, a vehicle condition data recognition unit, a vehicle control unit and a unit for controlling the vehicle actuator system based on the signals generated by the vehicle control unit, wherein the array of sensors includes at least two essentially horizontally directed range sensors at the front of the vehicle, at least one range sensor at the rear area of the vehicle, at least one trackable range sensor on the roof of the vehicle and directed at the roadway, ultrasonic sensors and/or microwave radar sensors arranged on each side of the vehicle, and at least one camera located in each of the front and rear areas of the vehicle.

31 Claims, 9 Drawing Sheets

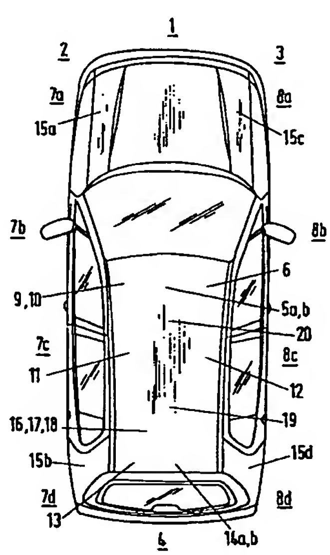


Fig. 1

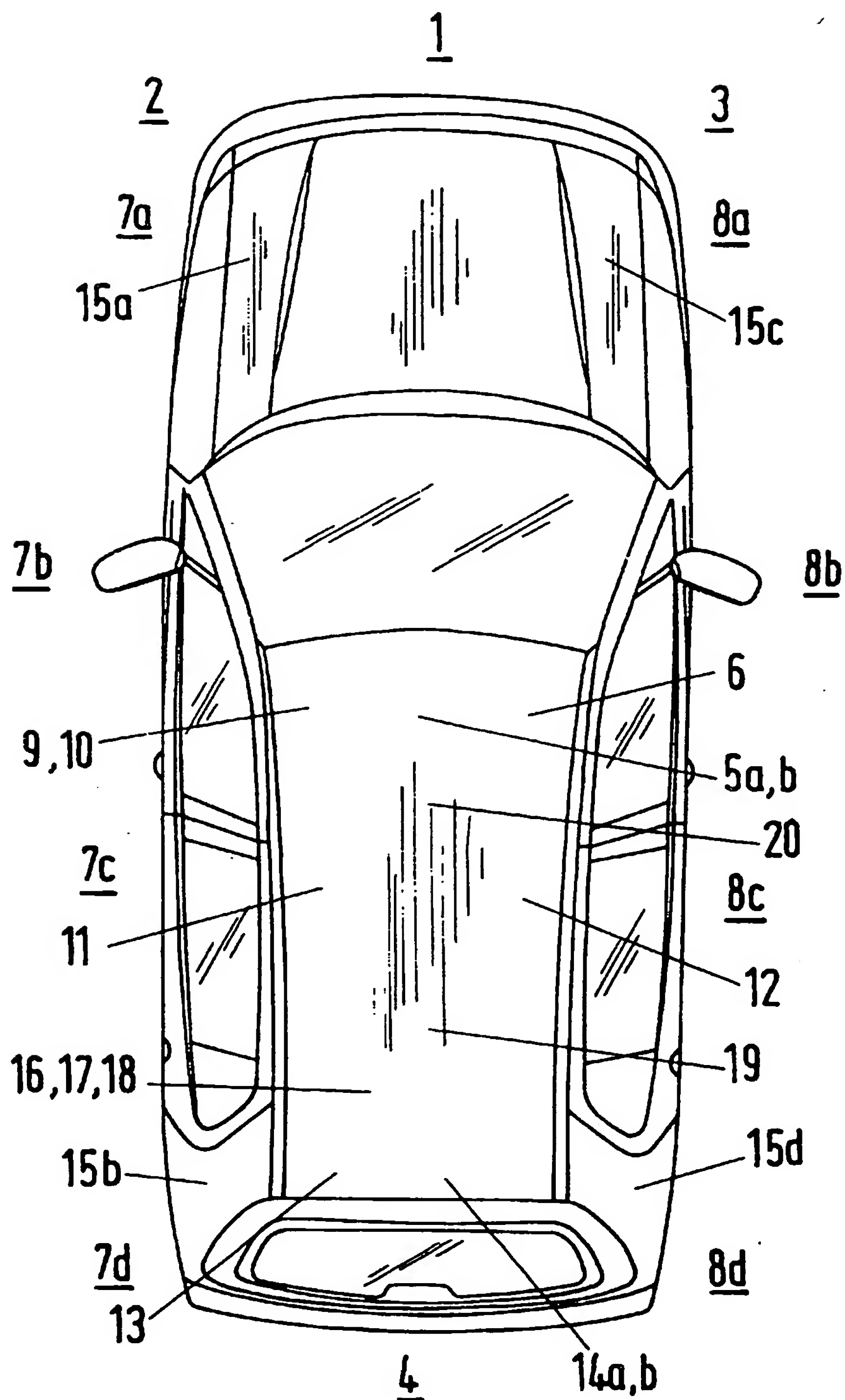

1
2
3
7a
8a
15a
15c
7b
8b
6
9,10
5a,b
20
7c
8c
11
12
19
16,17,18
15b
15d
7d
8d
13
4
14a,b

Fig. 2

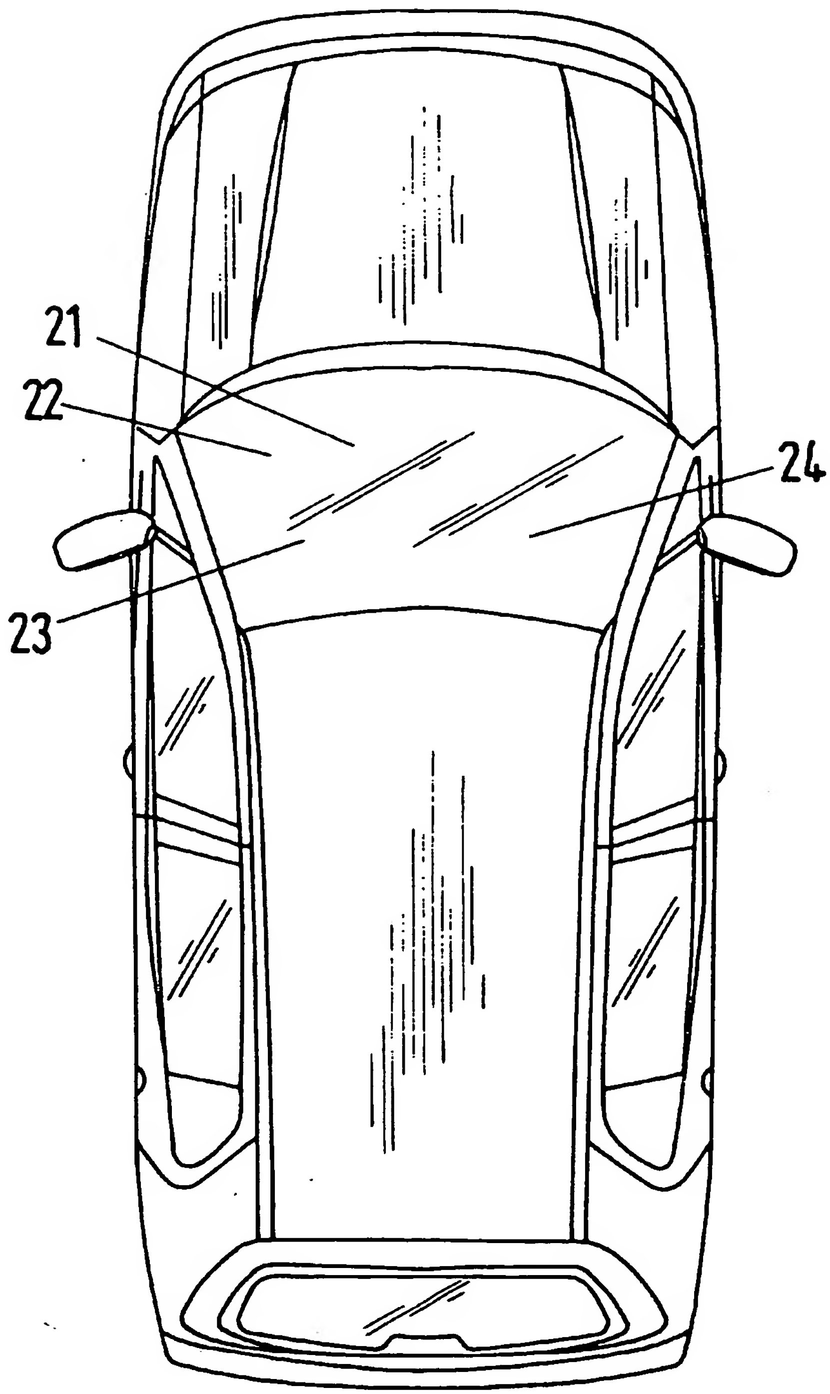


Fig. 3

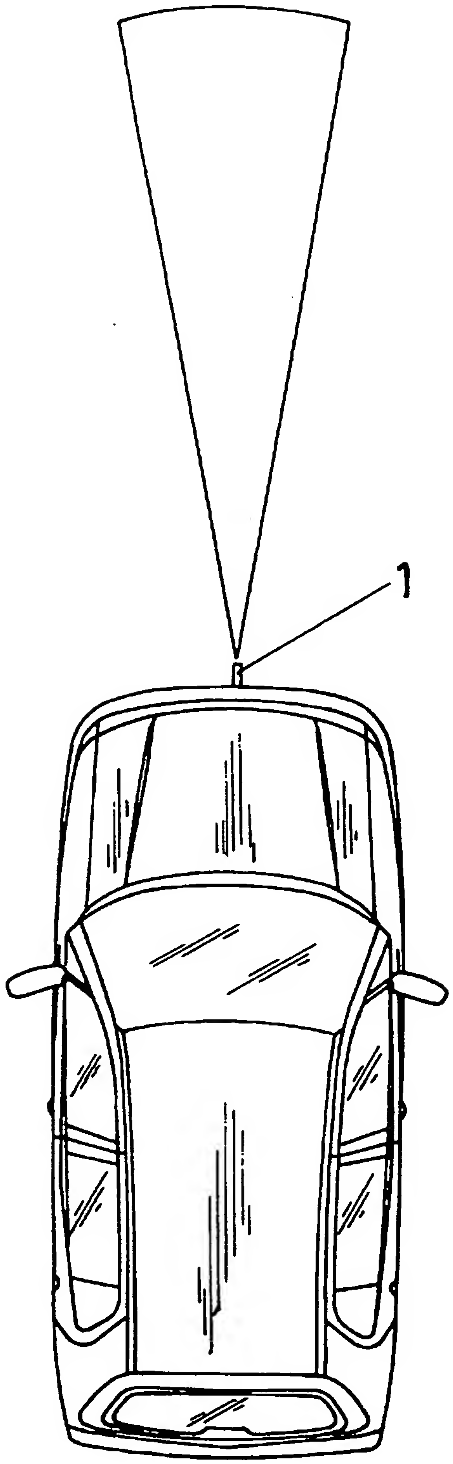


Fig. 4

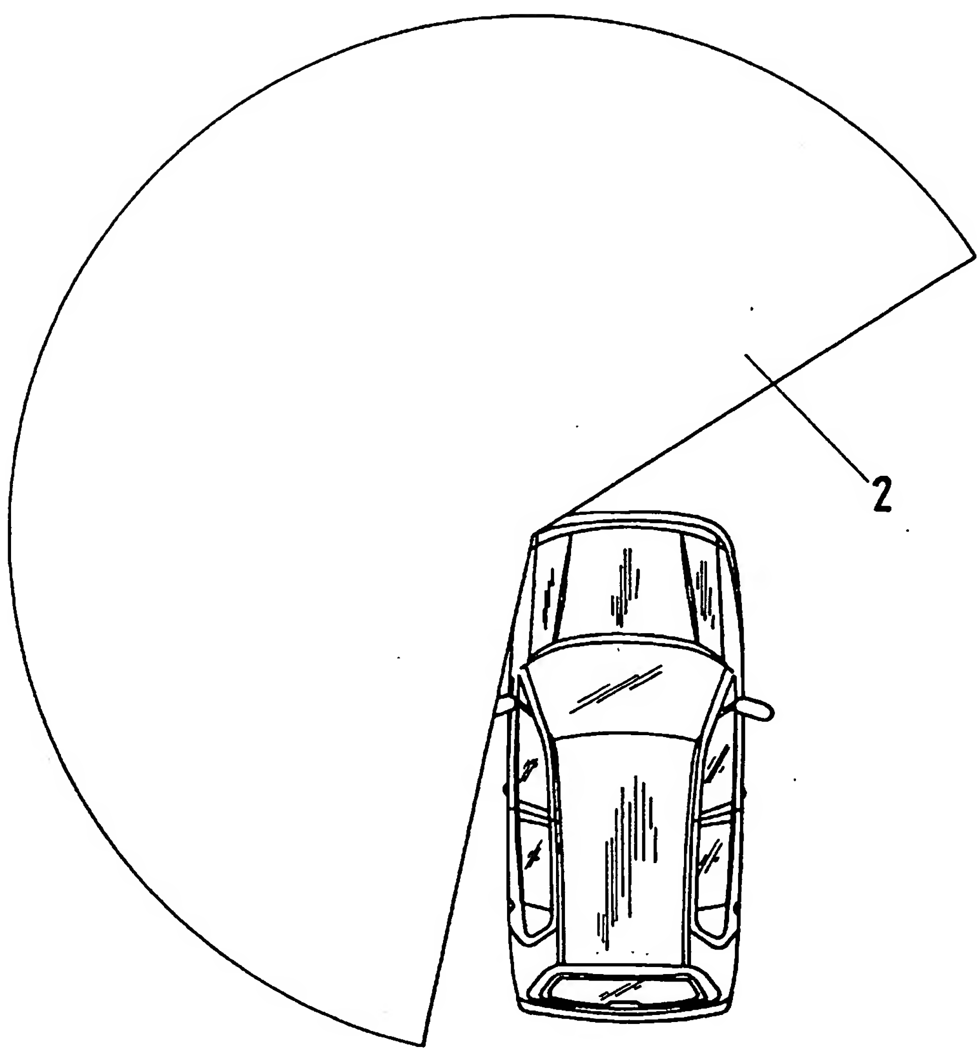


Fig. 5

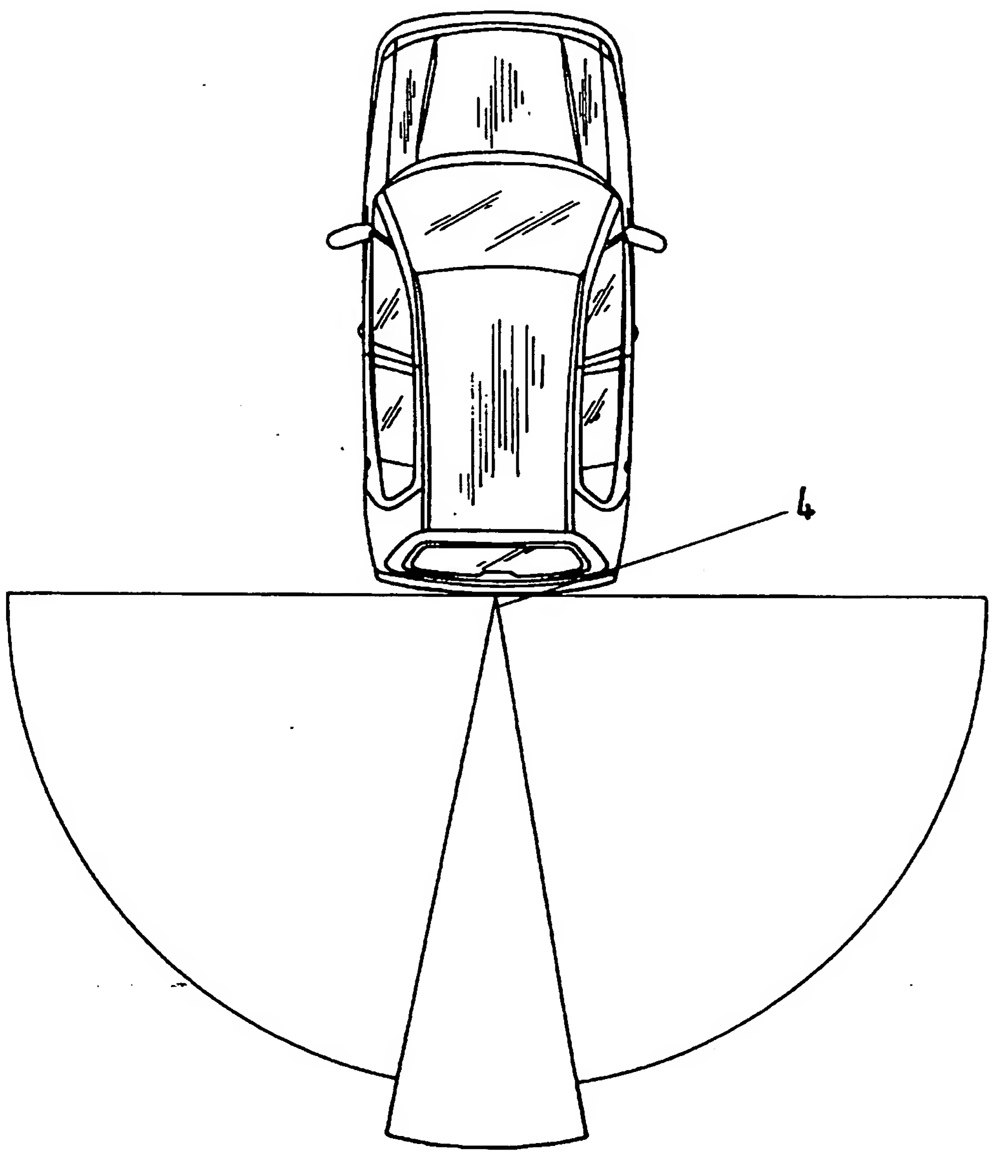


Fig. 6

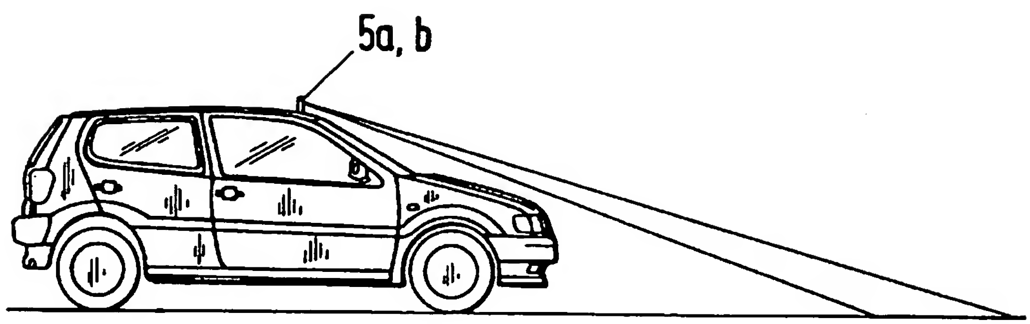


Fig.7

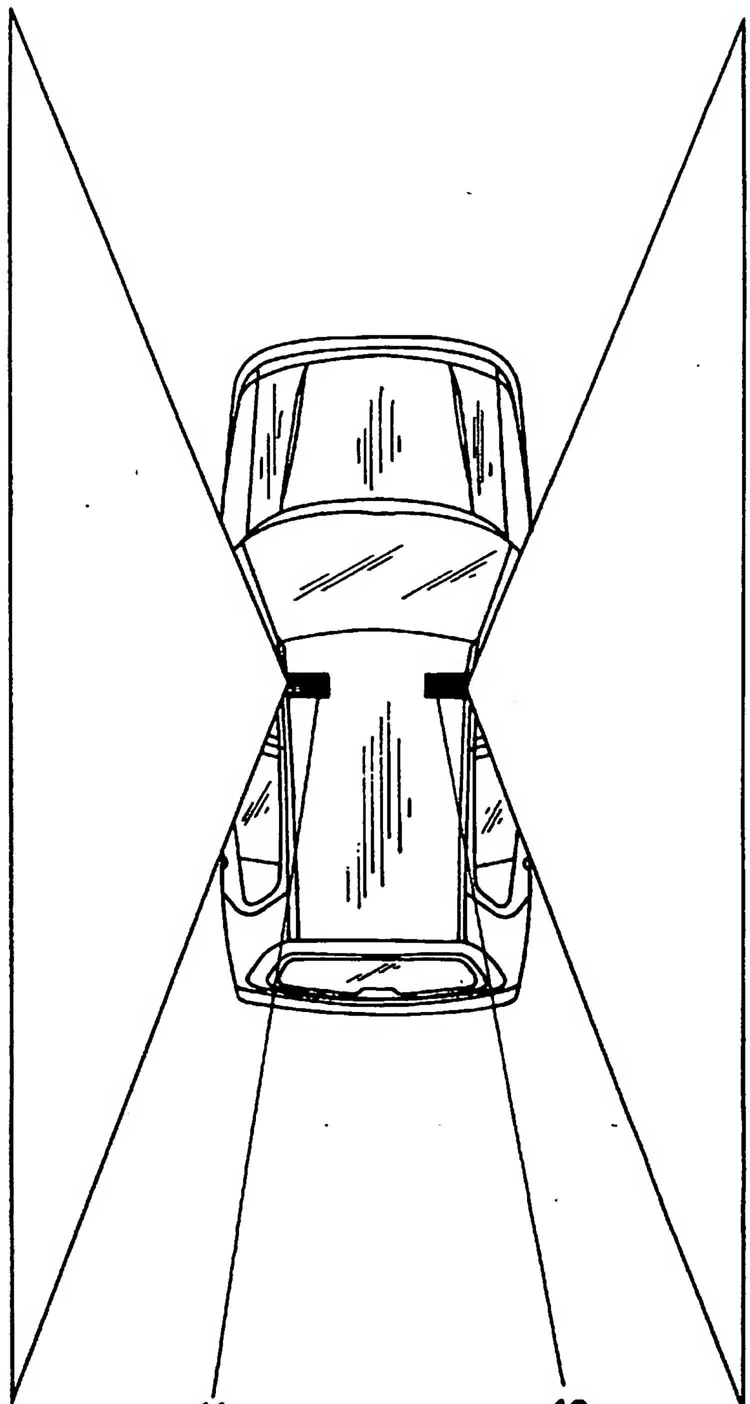


Fig. 8

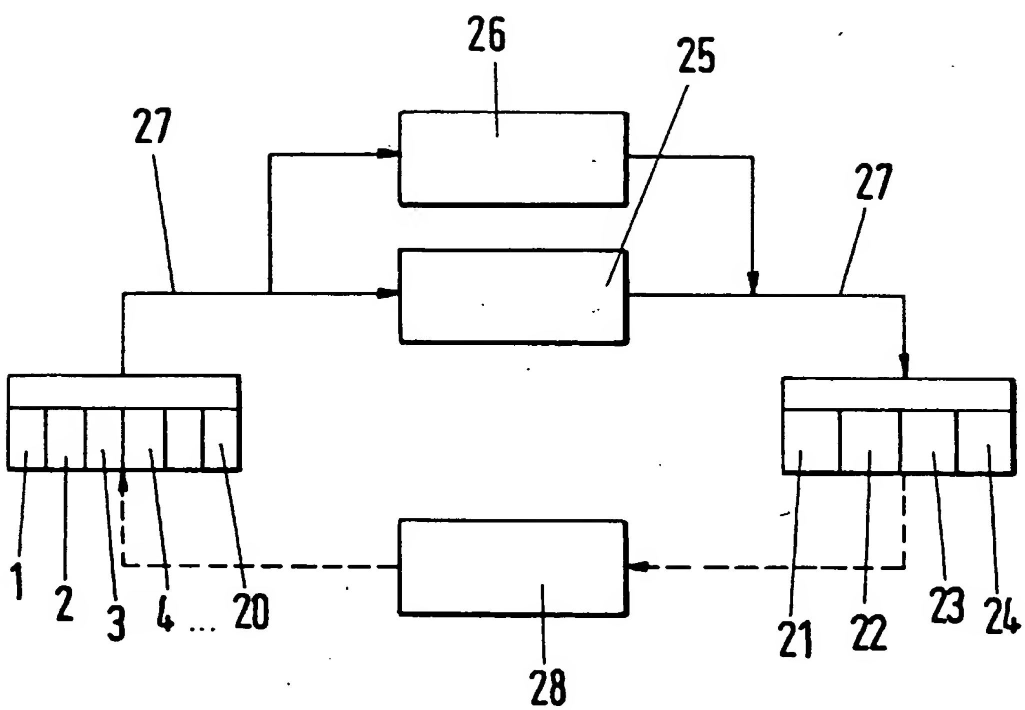
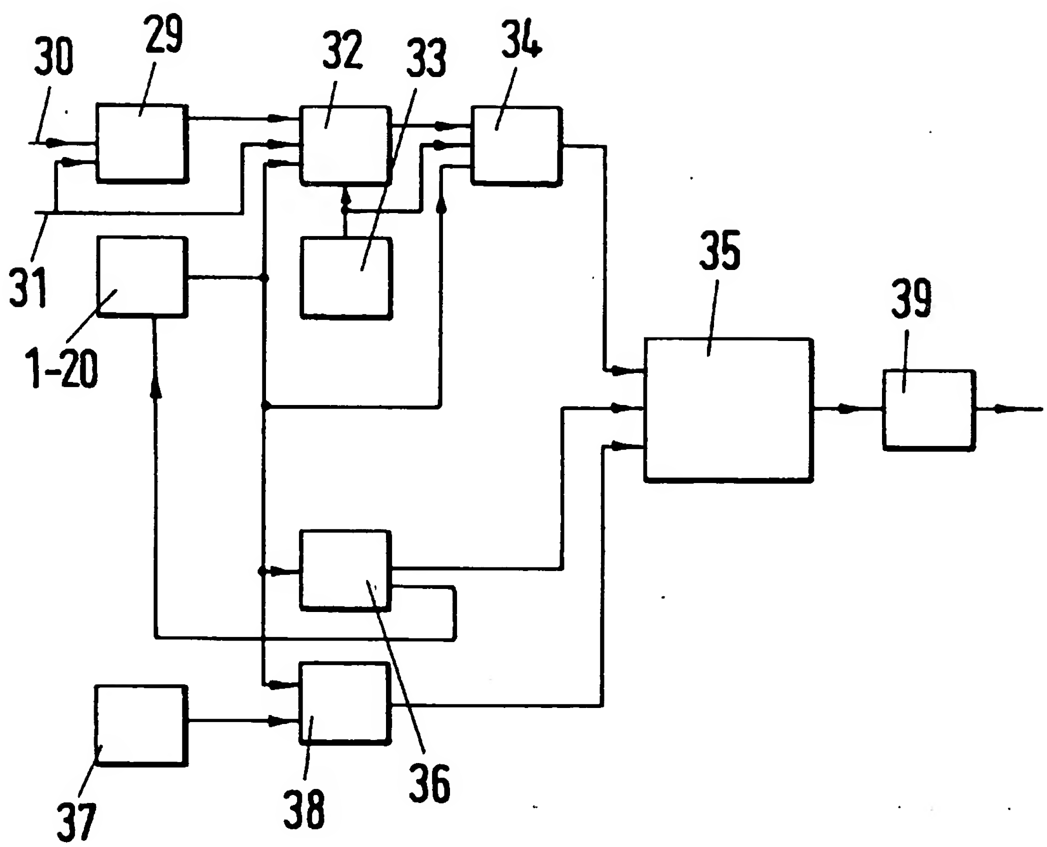


Fig.9



AUTONOMOUS VEHICLE ARRANGEMENT AND METHOD FOR CONTROLLING AN AUTONOMOUS VEHICLE

BACKGROUND OF THE INVENTION

This invention relates to an autonomous vehicle arrangement and methods for controlling autonomous vehicles.

Many efforts to provide autonomous vehicles have been made. As used herein "autonomous vehicle" means a driverless vehicle that moves independently from a point of origin to a destination, with or without human passengers. Autonomous vehicles must be distinguished from vehicles that are remotely controlled by wire or radio so that a person outside of the vehicle continues to take responsibility for the movement.

Autonomous vehicles have already reached such a standard in the field of materials transport that they have found a variety of industrial applications. Thus, autonomous vehicle arrangements have been proposed in which a guide cable or control wire is disposed along a route and the vehicle is guided along the guide cable. When a specific signal is transmitted to the guide cable, the presence of the signal is detected by a pickup coil installed on the vehicle, and the vehicle moves along the guide cable route, and any deviation from the prescribed route is determined with the aid of the guide cable. In a further conventional arrangement for an autonomous vehicle system, an optically reflecting tape, for example an aluminum or polyvinyl tape, is placed along the surface of the travel path instead of a guide cable, and a light projector and a photodetector are mounted on the autonomous vehicle. The light emitted by the projector is reflected by the tape and received by the photodetector and, in this way, the unmanned vehicle is guided along the reflecting tape. A disadvantage of the conventional autonomous vehicle arrangements is that desired vehicle routes cannot be freely chosen, but instead must be installed in advance.

U.S. Pat. No. 5,229,241 discloses an autonomous transport vehicle containing an image processing unit that photographs the environment in the forward direction of the vehicle and processes the photographed image, a position finding unit that calculates the position of the vehicle in an absolute coordinate system on the basis of information obtained from a wheel speed sensor, a gyroscope and the like, a drive unit that includes the vehicle's steering, gas pedal, brake system, turn signals and the like as well as actuators to operate these devices including the associated servo drivers, a unit in which are stored site plan data and map data regarding a destination and information defining a route, a travel control unit that controls the drive unit with the aid of the information obtained from the image processing unit, the position finding unit, and the information storage unit in such a way that the vehicle drives to a final destination, and a user interface for entry of information relating to a destination, i.e., a variety of destination points that are defined on the route by the travel control unit, and for display of the image obtained from the image processing unit as well as other information.

For this purpose, the image processing unit includes two cameras located at the front of the vehicle which record a stereo image of the environment. The spatial image photographed by the two cameras is converted through an inverse transformation in an image processing unit into a plane image. For instance, the image processing unit identifies a pair of white guide lines painted along the travel path, a travel path side boundary, a center line and the like, and measures the length of the lines in relation to the vehicle. In particular, through the sensing of the white lines on the travel path, the spatial relationship between the vehicle and the travel path is calculated, i.e. the distance of the vehicle from the white line on the left and/or right side of the travel path, the angle between the forward direction of the vehicle and the travel path, and the like and, in the case of a curved travel path, the direction of the curve is determined at half the distance of the travel path. In addition, the distance of the vehicle from an intersection is determined by detecting and measuring the intersection point of the white lines before the intersection is reached.

The image processing unit further contains an ultrasonic sensor, a laser radar and the like for detecting obstacles located on the travel path in front of the vehicle and to the side of the vehicle, as, for example, a vehicle traveling in front, a protective barrier, and the like, and for transmitting the corresponding information to a position finding unit of the vehicle. The position finding unit includes two wheel speed sensors that are located on the left and right rear wheels of the vehicle, a processing unit that receives and processes the output signals of the two wheel speed sensors, and a calculation unit for calculating the location of the vehicle in global coordinates. The wheel speed sensors detect the rotation of the vehicle's rear wheels and generate several thousand pulses per revolution for each wheel. When a difference is found in the number of pulses generated for the individual wheels, this means that there is a difference in the distance covered by the corresponding wheels, and this difference in the distance covered forms the basis for determining the curvature of the section of travel path being traveled by the vehicle. In addition, the distance covered by both wheels indicates the distance traveled by the vehicle. The path of the vehicle can thus be calculated on the basis of the sequences of data provided by the wheel speed sensors. In particular, information relating to the location and position of the vehicle at a specific point in time, i.e. information regarding the vehicle's location and direction of travel in an X-Y coordinate system, can be derived.

If the vehicle location is known at the start of the trip, the current location of the vehicle during the trip can be monitored continuously, since the wheel speed data is processed sequentially. Because the errors in the determination of vehicle location accumulate, the measurement errors increase with increasing distance traveled by the vehicle. For this reason, a gyroscope is provided so that the position in an absolute coordinate system can be determined with high accuracy. However, such an autonomous vehicle for material transport is only suitable for use in defined areas, such as manufacturing halls or an industrial plant, where nearly identical external conditions prevail.

In addition, German Offenlegungsschrift No. 41 24 654 describes a method for continuous and automatic vehicle orientation on a travel path in which an automatic vehicle guidance system is provided for better utilization of transport capacity of traffic routes. In this method, a television camera that is mounted on the vehicle as high as possible above the travel path continuously transmits digitized image sequences at the video rate to a computer system with a program for special signal processing and interpretation in the vehicle. In this method, generic street models and simple, generic, dynamic models for the vehicle movement are utilized in order to be able to use previously incorporated travel path recognition and relative vehicle position recognition to evaluate the next image. For this purpose, three partial models are combined. Monocular image data of only the last image are analyzed with recursive estimation meth-

ods to determine street parameters and the vehicle's location with respect to the streets. In this way, a spatial projection is produced in the computer of the current street path in the area of prediction.

U.S. Pat. No. 5,610,815 discloses an autonomous vehicle, specifically for use in open-pit mining, that has a first position finding system based on GPS (Global Positioning System) and a second IRU (Inertial Reference Unit) positioning system based on a gyroscope, and the data from these systems are computed together in a third position finding system for accurate position determination. In addition, the autonomous vehicle contains a navigation system by which the vehicle can be guided on predefined or dynamically determined routes. The navigation system monitors the current position as well as the mechanical vehicle components such as brakes, steering and motor, and can shut down the vehicle if serious malfunctions occur. Moreover, the navigation system includes an obstacle detection device in order to detect objects located on the planned route and, if necessary, to steer an avoidance course or stop the vehicle. For this purpose, an infrared laser scanner in single line mode is placed on the roof of the vehicle, where the scanning angle is between 10° and 30°. The scanning beam is oriented in such a way that it does not reach the ground. This ensures that detected obstacles are not the result of irregularities in the ground. For detection of ground irregularities, a second laser scanner in multiple line mode is aimed at the ground at a specific angle. That angle is selected in such a way that obstacles are detected at a distance corresponding to the vehicle stopping distance so that the vehicle can be stopped in time before reaching the obstacle.

This autonomous vehicle designed especially for open-pit mining is very advanced in the areas of position finding and route generation, but does not take into account important aspects for the use of an autonomous vehicle in traffic on public roads. Thus, for example, a limitation of the field of view to be evaluated is not possible in street traffic, since vehicles on merging streets must be detected in advance in a timely manner, on the one hand in order to adapt the driving behavior to the applicable traffic regulations, and on the other hand also to be able to react preventively to improper behavior of a vehicle on a merging street. This illustrates that, while basic structures of the known autonomous vehicles are generally suitable in part, as, for example, the position finding system, others are inadequate in the known art.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an autonomous vehicle arrangement and a method for controlling an autonomous vehicle that overcomes the disadvantages of the prior art.

Another object of the invention is to provide an autonomous vehicle that is suitable for use in traffic on public roads, as well as a method for controlling one or more autonomous vehicles.

These and other objects of the invention are attained by providing an autonomous vehicle arrangement having a vehicle control unit, a system for actuating vehicle components based on signals generated by the vehicle control unit, and an array of sensors for detecting objects and conditions along a route to be followed by the vehicle including at least three range sensors mounted at the front of the vehicle, at least one range sensor mounted at the rear of the vehicle, at least one ultrasonic or microwave sensor mounted on each side of the vehicle, and at least one camera mounted at each of the front and rear areas of the vehicle. Preferably, a thermal imaging camera for detecting the presence of living creatures is mounted at the front region of the vehicle.

In accordance with the method of the invention a desired travel destination for the vehicle is entered in an input unit, the current location of the vehicle is determined, and an optimal travel route is planned by a route planner taking into account traffic information, information previously stored in a digital map, and information detected by sensors on the vehicle, and corresponding signals are supplied to a vehicle control system which controls vehicle actuators in accordance with the received signals.

In this arrangement, various sensors which are conventional in motor vehicles are synergistically used together so that the array of sensors can, in the broadest sense, reliably detect and appropriately react to all surrounding objects and/or obstacles under all weather conditions and in a wide variety of traffic situations, including operation on roads. This also makes it possible to use an autonomous vehicle in traffic on public roads or in other complex environments.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects and advantages of the invention will be apparent from a reading of the following description in conjunction with the accompany drawings, in which:

FIG. 1 is a top view showing a representative embodiment of an autonomous vehicle according to the invention having an array of sensors;

FIG. 2 is a top view of an autonomous vehicle showing a vehicle actuator system;

FIG. 3 is a top view showing the radiation pattern of a radar sensor;

FIG. 4 is a view showing the radiation pattern of a laser scanner sensor in the front area of the vehicle;

FIG. 5 illustrates the radiation pattern of a laser scanner sensor in the rear area of the vehicle;

FIG. 6 is a side view showing the radiation pattern of a laser scanner sensor directed at the roadway in the front area of the vehicle;

FIG. 7 is a top view showing the scanning pattern of two cameras located at the sides of the vehicle;

FIG. 8 is a schematic block diagram illustrating the top hierarchical level of the autonomous vehicle; and

FIG. 9 is a block diagram illustrating the arrangement of a system for generating a virtual guide wire.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 illustrates schematically a top view of a typical embodiment of an autonomous vehicle according to the invention schematically showing a variety of sensors having individual modes of operation and function which are explained below. At least one radar sensor 1 is mounted in the front area of the autonomous vehicle. Such radar sensors are known, for example, from range finding devices, for example ADR (Automatic Distance Regulation), used in vehicles. Using the radar sensor 1, the number of objects in the area in front of the autonomous vehicle, their distance from it, and their relative speed can be determined, for example. Because of the strictly limited horizontal detection range of radar sensors, they are provided solely for object detection in front of the vehicle. The radiation pattern of the radar sensor 1 is shown in FIG. 3.

The advantage of radar as compared to optical sensing equipment is that radar retains its performance capability even under adverse weather conditions such as fog, snow, rain and dust. This advantage requires the radar sensor **1** to be used in support of two laser scanner sensors **2** and **3**, which are also used for object detection, in particular for object detection at intersections and lane merges. The laser scanner sensors **2** and **3** are located near the front corners of the vehicle, for example in the fenders. The two dimensional laser scanner sensors **2** and **3** each have a horizontal detection range angle of about 270° so that only one additional laser scanner sensor **4** with a horizontal range angle of 180° need be provided in the rear area of the vehicle. The radiation pattern of the laser scanner sensor **2** is shown in FIG. **4**. The laser scanner sensor **3** has a corresponding pattern so that the two front corner laser scanners cover essentially the entire front and side areas of the vehicle.

3

Since only the aforementioned 180° angle in the rear area is required for the laser scanner sensor **4** for full all-around sensing, the remaining 180° of the potential scanning range of the laser scanner sensor **4** can be used for additional coverage within an inner 30° detection range as shown in FIG. **5**, so that this laser scanner sensor provides quasi three-dimensional object detection in the middle area of that region. In case of failure of the laser scanner sensor **4**, limited driving operation is still possible, but turning maneuvers may no longer be performed.

Furthermore, it is advantageous to provide an additional downwardly directed laser scanner sensor **5***a*, shown in FIG. **6**, on the front of the roof or on the windshield in the rear-view mirror region having the primary task of detecting holes in the ground or small obstacles on the ground. For this purpose, the angular orientation of the beam of the laser scanner sensor **5***a* in the vertical direction can be changed as a function of the vehicle speed and the weather to detect holes or obstacles before the vehicle reaches the hole or obstacle, if necessary. In contrast to the conventional arrangements, the orientation of this sensor is varied as a function of the weather conditions, since such conditions, in addition to the vehicle speed, have a critical effect on the length of the vehicle stopping distance. If an object traveling in front of the vehicle is located in the beam path of the laser scanner sensor **5***a*, that sensor takes over the task of sensing and tracking the object. The laser scanner sensor **5***a* has a horizontal detection angular range of 45° and vertical angular range of 5°. Because of the large horizontal detection range, this sensor can also assist in lane recognition and in recognition of the side edges of the lane or road.

5

As described hereinafter, a failure of the laser scanner sensor **5***a* would require immediate stopping of the autonomous vehicle. In order to avoid this problem, an identical laser scanner sensor **5***b* is preferably provided, either to immediately take over the tasks of laser scanner sensor **5***a* should it fail, or to operate concurrently with the laser scanner sensor **5***a* in order to provide a redundant overall system.

Because of the vertically limited field of view of the laser scanners **5***a* and **5***b*, an additional laser scanner sensor **6**, which has the same horizontal and vertical detection range as the sensors **5***a* and **5***b* but is fixed in position, is provided at the top of the vehicle for the detection of clearance heights. In addition to clearance height detection, the laser scanner sensor **6** can also be used to assist in object recognition. A prerequisite for this, however, is screening of the laser scanner sensors **5***a* and **5***b* with respect to the laser scanner sensor **6**. Failure of the laser scanner sensor **6** can be compensated by taking the clearance heights on the route directly from a digital map so that immediate shutdown of the autonomous vehicle in the event of such failure is not necessary.

At slow speeds of travel and when parking, it is not possible to completely detect objects along the flanks of the vehicle with the front corner laser scanner sensors **2** and **3**. Consequently, for side detection, four ultra-sonic sensors **7***a*–**7***d* and **8***a*–**8***d*, for example, are mounted along opposite sides of the vehicle. These sensors can also be used to assist in road edge detection at slow speeds of travel.

Also mounted on the front part of the roof of the vehicle is a video camera **9** which serves primarily for lane recognition. Additionally, however, the video camera **9** can aid in road edge detection and object recognition. Furthermore, the camera **9** can also be used to assist the laser scanner sensor **6** in clearance height detection.

An additional video camera **10**, located in the front area of the roof, is used for lane, object and/or traffic sign recognition. The cameras **9** and **10** can also be combined into a mutually complementary system with the camera **9** set up for far field recognition and the camera **10** set up for the near field recognition.

For detection of neighboring lanes and thus also detection of the vehicle's own lane and of the edge of the road, the autonomous vehicle has additional video cameras **11** and **12** arranged on each side of the roof with lateral sensing patterns shown in FIG. **7**. By mounting another video camera **13** in the rear region of the autonomous vehicle, support for the lane and road edge recognition is also possible. The primary task of the video camera **13**, however, is for support of the quasi three-dimensional laser scanner sensor **4** for object recognition.

For high-precision position finding, a DGPS (Differential Global Positioning System) is mounted on the roof of the vehicle. This sensor, in conjunction with a digital map, determines the absolute position of the autonomous vehicle in world coordinates. Such digital maps are conventional, for example, in navigation systems for modern motor vehicles. A failure of the DGPS sensor **14***a* would also lead to immediate stopping of the autonomous vehicle, as will be described later. In order to avoid this problem, an identical DGPS sensor **14***b* is preferably included in order to immediately take over the tasks of the DGPS sensor **14***a* should it fail. Moreover, both DGPS sensors **14***a* and **14***b* can be used in parallel to provide redundancy. In addition, a gyroscope or a gyroplatform can be used in order to be able always to determine exactly the position of the autonomous vehicle even in circumstances of radio frequency shielding, for example in a tunnel.

In addition, each of the individual wheels of the vehicle has a wheel sensor **15***a*–**15***d*, by which the coefficient of road friction can be detected.

Also arranged on the roof of the autonomous vehicle are an air pressure sensor **16**, a humidity sensor **17** and a temperature sensor **18**. The data supplied by these sensors **16**–**18** are used to infer the current and expected weather conditions. These results are used for such purposes as verification of the results of the individual sensor systems, for example to determine the visibility conditions that can be expected and to coordinate with the visual ranges as determined by the laser scanner sensors **2**–**6**.

Moreover, four directional microphones **19** combined with corresponding loudspeakers are also arranged on the autonomous vehicle. The microphones detect acoustic signals such as police and fire sirens, railroad crossings and the like. The loudspeakers permit the vehicle control center to

be in verbal and communicative contact with any passers-by. For verbal announcements that do not require a response, the loud speakers can also be used directly by the autonomous vehicle.

Also arranged at the front of the roof is a thermal imaging camera **20** for the purpose of assisting the object detection system by providing a temperature profile and thus distinguishing motionless persons at the side of the road from inanimate objects, for instance. Furthermore the thermal imaging camera **20** is also suitable to a limited extent for performing lane and road edge detection. Advantageously, the individual cameras **9**–**13** and **20** are provided with a cooling system in order to compensate for heating as by direct solar radiation. Moreover, shielding measures can be taken in order to avoid dazzling of the cameras **9**–**13** and **20** by direct solar radiation or as a result of reflections from wet pavement.

FIG. **2** is a top view of the autonomous vehicle with a schematic arrangement of possible actuators. The autonomous vehicle comprises at least one electrically controlled accelerator **21**, one electrically controlled brake **22** and one electrically controlled steering system **23**. If the vehicle is not equipped with an automatic transmission, an electrically controlled clutch **24** is additionally required. Such electrically controlled devices are known in basic principle from conventional motor vehicle technology as x-by-wire systems. In such systems, a mechanical control motion is converted into an electrical actuating signal so that the actuator, such as a pedal, is mechanically decoupled from the device to be controlled.

Since no human being is present to actuate the pedals or the steering wheel in the autonomous vehicle, the mechanical movement of the actuators must be replaced. In principle, two alternative arrangements are possible for this purpose. In one arrangement, the mechanical movement can be generated by a robot driver so that the conventional mechanical devices do not have to be modified. In another arrangement, the mechanical movement is eliminated entirely and the vehicle control device directly generates electrical control signals for the control units of the individual actuators. The operation of additional components, as, for example, the lighting system of the autonomous vehicle, is effected similarly.

FIG. **8** is a schematic block diagram showing the top hierarchical level of the autonomous vehicle. The array of sensors **1**–**20** acquires information from the autonomous vehicle itself and its environment **28** and transmits such information to a vehicle computer **25** and to a collision avoidance device **26**. The vehicle computer, by which the actual control of the autonomous vehicle takes place, and the collision avoidance device **26** work in parallel for safety reasons, so that the collision avoidance device **26** is effective to act upon the actuators **21**–**24** only to avoid a collision hazard. In normal operation, control of the actuators **21**–**24** is carried out exclusively by the vehicle computer **25**. Data transmission from the sensors **1**–**20** to the vehicle computer **25** and to the collision avoidance device **26**, and also to the actuators **21**–**24** takes place over CAN (Controlled Area Network) buses **27**. In this process, the data are preferably distributed over several CAN buses **27** in order to assure reliable transmission of the volumes of data that are generated.

Since real-time processing of the data is necessary, the CAN buses **27** should not be operated at the upper limit of their transmission capacity. The preprocessed data from the individual sensors must therefore be transmitted separately from one another and reassembled in the downstream analysis units into an overall image on the basis of time sharing. In this context, a hierarchical principle with appropriate filter algorithms for information compression should be used as much as possible so as not to overload the analysis units.

FIG. **9** shows a block diagram of an arrangement for generating a virtual guide wire. This arrangement comprises an input unit **29** to receive one or more travel orders that can be supplied over an internal connection **30** as well as from an external communication connection **31**, for example, in the form of a mobile radio telephone. Depending on the application for the autonomous vehicle, the travel orders can contain further information in addition to the actual destination. For example, if the autonomous vehicle is to be used in public local passenger transport, the number of passengers to be carried is necessary as additional information in order to match this with the capacity of the vehicle. Moreover, the urgency of the travel order can also be taken into account. Such algorithms are already in use, for example for operations planning programs in local public transport, and are usable in principle.

In contrast, if the autonomous vehicle is used as an individual vehicle, the external communication connection **31** for the input **29** can be dispensed with, since only the user of the vehicle will issue the travel orders. The travel order or orders registered in the input unit **29** are then transmitted to a route planning unit **32**. In addition, the route planning unit **32** receives the precise current position of the vehicle from the DGPS sensors **14*a*** and **14*b*** as well as traffic information from the external communication connection **31**. The traffic information can include, for example, reports of traffic congestion, construction sites and information on large events such as concerts, demonstrations, soccer games or the like.

By using a digital map **33** which is associated with the route planning unit **32**, the route planning unit determines an optimal route from the then current position to the desired destination, taking into account the traffic information from the external communication connection **31**. The optimal route can be chosen in terms of either travel time or minimum fuel consumption. In addition to an actual street layout, the digital map **33** contains information such as clearance heights for bridges, the number of lanes in a road, traffic signs, and the like. Such digital maps **33** are already known for navigation assistance systems in motor vehicles. The optimal route is produced by the unit **32** in the form of a series of route segments, and each current route segment, and if necessary the subsequent route segment, is supplied to a vehicle path generation unit **34**. The vehicle path generation unit determines an optimal vehicle path for the supplied route segment.

In addition to the vehicle path as such, the optimal path also includes information on the permissible maximum speeds for individual route segments, which lane should be selected, the radii of curves, traffic lights, right-of-way signs, stop signs, intersections, and where and how turns must be made. Such very precise information is necessary since the autonomous vehicle cannot act intuitively as a human being can. For example, even though he soon will have to turn left, a human driver drives as long as possible in the right or center lane so that he will not be obstructed by vehicles turning left at preceding intersections, and then switches to the left turning lane depending on the traffic situation. The other information is necessary so that the autonomous vehicle can adapt its driving behavior in a timely fashion. This is important particularly with regard to other traffic participants, for whom very abrupt driving behavior is

irritating and could lead to incorrect judgments. Since not all information regarding the infrastructure is contained as advance information in the digital map 33, for instance because new traffic signs have been installed, the vehicle path control unit 34 is additionally supplied with the acquired sensor signals from the sensors 1–20, from which additional infrastructure information can be taken, for example the traffic signs detected by the video camera 10 or the weather conditions detected by the sensors 16–18, upon which the maximum permissible speed can depend, for example. The optimal vehicle path, which one could also refer to as a virtual ideal control wire, is determined from all this information. The generated ideal path is transmitted together with the current visual sensor information from the sensors 9–13 and 20.

The acquired sensor signals from the sensors 1–20 are also supplied to an object recognition unit 36. The object recognition unit 36 analyzes the information according to whether one or more objects were detected, what type of objects are involved (for example, moving or stationary), and, if necessary, generates control signals for the tracking motion of individual sensors, such as the camera 9, for example. In order to be able to draw exact conclusions concerning the nature and type of object or obstacle based on the sensor data, the prevailing weather conditions must be known. These can be determined primarily from the information from the sensors 16–18. Since the unit 34 for generation of a vehicle path also requires the weather conditions, these can also be centrally determined and supplied to the appropriate components.

In addition, the object recognition unit 36 analyzes the sensor information according to how much traffic-free area exists around the vehicle even beyond the current vehicle position. This information is particularly important for the execution of any necessary avoidance maneuvers. The principle mode of procedure in the analysis of sensor information in this context is known to the expert, for example from ADR (Automatic Distance Regulation) systems. An additional factor here is that the various sensor information from the different sensors such as the radar sensor 1 and the laser scanner sensors 2 and 3 must be weighted or reconciled with one another as a function of weather conditions. The object recognition unit 36 supplies to a vehicle control unit 35 the calculated traffic-free area, the detected, tracked and classified objects with their condition vectors, i.e. location, relative velocity, etc., as well as the prevailing weather conditions.

In addition to the sensors 1–20 listed above, the autonomous vehicle also has further sensors 37 providing information to a unit 38 for vehicle condition data recognition which assembles and generates general data relating to the condition of the vehicles and the condition vector for the vehicle itself. The sensors involved here are adequately known in terms of type and arrangement from modem motor vehicles so that a more detailed explanation is not necessary. Taken into account here in particular are vehicle conditions such as the engine speed, vehicle speed, ABS sensor information, coefficients of friction, steering angle, and the like, and information from the sensors 1–20, for example the wheel sensors 15, is also included. In addition, the sensors 37 can generate a status report for any subsystem. The status reports and the vehicle condition vector are likewise supplied to the vehicle control unit 35.

The vehicle control unit 35 then generates from all the supplied information a real control vector which is transmitted to a vehicle actuator control unit 39 for the vehicle actuators 21–24 as well as passive vehicle components such as the turn signals, the vehicle lighting system, the windshield wiper system, and the like. In contrast to the optimal vehicle path determined by the unit 34, this control vector also takes into account dynamic changes such as the presence of detected and moving objects or the color of the traffic signal. For each section, the control vector thus contains a set of control commands for the actuators 21–24 and vehicle components to be operated, where the rate of change of the control vector is dependent on the infrastructure and the surrounding traffic. The traffic regulations to be observed, for example, right before left at an intersection with equal right of way, are stored in the vehicle control unit 35 in the form of algorithms. Since the number of traffic signs accompanied by frequent changes in right-of-way situations is very large, especially in city driving, either as many traffic signs as possible must be integrated in the digital map 33 or, preferably, a parallel processing system is provided since otherwise the vehicle speed must be adapted to the processing speed of the vehicle control unit 35, which under certain circumstances could be perceived as irritating by human drivers. In order to increase the acceptance of autonomous vehicles among passengers as well as among other traffic participants, the vehicle control unit 35 can additionally be provided with a human driving strategy, for example a slow approach to a red light.

Although the invention has been described herein with reference to specific embodiments, many modifications and variations therein will readily occur to those skilled in the art. Accordingly, all such variations and modifications are included within the intended scope of the invention.

We claim:

1. An autonomous vehicle arrangement, comprising:

an input unit for travel orders;

a vehicle route planning unit comprising at least one position finding unit and a digital street map;

a vehicle path generating unit for generating a vehicle path from a present location to a designated destination;

a plurality of sensors including at least one range sensor for detecting objects and condition features of the vehicle path;

a collision avoidance unit;

a vehicle condition data recognition unit;

a vehicle control unit; and

a vehicle actuator control unit for controlling vehicle drive system actuators based on signals generated by the vehicle control unit;

wherein the plurality of sensors includes:

at least one range sensor located in a front area of the vehicle;

at least one range sensor located in a rear area of the vehicle;

a plurality of ultrasonic and/or microwave radar sensors located at the sides of the vehicle; and

at least one camera located in each of the front and rear areas of the vehicle.

2. An autonomous vehicle arrangement in accordance with claim 1 wherein the plurality of sensors includes two laser scanner sensors directed essentially horizontally and arranged in a front area of the vehicle.

3. An autonomous vehicle arrangement in accordance with claim 2 wherein the laser scanner sensors have a horizontal detection range angle of about 270°.

4. An autonomous vehicle arrangement in accordance with claim 1 wherein a range sensor located in the rear area of the vehicle is a laser scanner sensor.

5. An autonomous vehicle arrangement in accordance with claim 4 wherein the laser scanner sensor in the rear area is effective at least partially as a three-dimensional laser scanner.

6. An autonomous vehicle arrangement in accordance with claim 1 wherein a range sensor located in the front area of the vehicle is a radar sensor.

7. An autonomous vehicle arrangement in accordance with claim 1 including a further range sensor which is adjustable in sensing range as a function of vehicle speed and/or weather conditions.

8. An autonomous vehicle arrangement in accordance with claim 7 wherein the further range sensor is a laser scanner sensor directed toward the roadway in front of the vehicle.

9. An autonomous vehicle arrangement in accordance with claim 8 wherein the laser scanner sensor directed toward the roadway is mounted near the forward end of the roof of the vehicle.

10. An autonomous vehicle arrangement in accordance with claim 8 wherein the laser scanner sensor is mounted behind the windshield of the vehicle in a rear-view mirror area.

11. An autonomous vehicle arrangement in accordance with claim 1 wherein the cameras located in the front and rear areas of the vehicle are arranged for recognition of objects and/or traffic signs and/or lanes.

12. An autonomous vehicle arrangement in accordance with claim 8 wherein the further range sensor has a horizontal detection range and a vertical detection range and the horizontal detection range is greater than the vertical detection range.

13. An autonomous vehicle arrangement in accordance with claim 8 wherein the further range sensor is designed with redundancy.

14. An autonomous vehicle arrangement in accordance with claim 1 including an additional range sensor having a fixed setting and scan angle located on the roof of the vehicle for sensing allowable clearance heights.

15. An autonomous vehicle arrangement in accordance with claim 14 wherein the additional range sensor is a laser scanner sensor.

16. An autonomous vehicle arrangement in accordance with claim 1 including a first camera for near field recognition and a second camera for far field recognition mounted in the front area of the vehicle.

17. An autonomous vehicle arrangement in accordance with claim 1 including a front-facing camera arranged on each side of the vehicle.

18. An autonomous vehicle arrangement in accordance with claim 1 wherein the cameras are CCD cameras.

19. An autonomous vehicle arrangement in accordance with claim 1 including at least one wheel sensor for each of the wheels of the vehicle for detection of the coefficient of road friction.

20. An autonomous vehicle arrangement in accordance with claim 1 wherein the plurality of sensors includes at least one of a temperature sensor, a humidity sensor and an air pressure sensor.

21. An autonomous vehicle arrangement in accordance with claim 1 including at least one microphone and/or at least one loudspeaker.

22. An autonomous vehicle arrangement in accordance with claim 1 including a thermal imaging camera mounted in the front area of the vehicle for the detection of living creatures.

23. An autonomous vehicle arrangement in accordance with claim 1 wherein the position finding device includes a DGPS sensor.

24. An autonomous vehicle arrangement in accordance with claim 23 wherein the DGPS sensor is designed with redundancy.

25. An autonomous vehicle arrangement in accordance with claim 1 wherein the vehicle actuator control unit includes at least one of an x-by-wire system and a driving robot.

26. An autonomous vehicle arrangement in accordance with claim 1 including an external communication system connected to at least one of the route planning unit and the input unit for travel orders.

27. An autonomous vehicle arrangement in accordance with claim 1 wherein the position finding unit includes a gyroscope or a gyroplatform.

28. An autonomous vehicle arrangement in accordance with claim 1 including a vehicle computer and at least one data bus connecting the vehicle computer to the plurality of sensors or to the vehicle drive system actuators.

29. An autonomous vehicle in accordance with claim 1 wherein the data bus is a CAN bus.

30. A method for controlling an external communication system of an autonomous vehicle having an input unit for travel orders, a route planning unit containing a position finding device and a digital street map, a vehicle course generating unit for generating a vehicle course from a present location to a desired destination, an external communication system, an object recognition device, a vehicle control unit, a vehicle drive system actuation and a plurality of sensors, comprising the following steps:

a) providing an input to the input unit representing a desired travel destination;

b) transmitting the input travel destination to the route planning unit;

c) detecting the current vehicle location by the position finding device;

d) determining a route, defined in route segments, from the current vehicle location to the travel destination by a digital map and optimization algorithms, taking into account any traffic information provided over the external communication system;

e) transmitting to the vehicle course generating unit from the route planning unit the individual route segments to be traveled and the current location of the vehicle;

f) generating an optimized course for the transmitted route segments, taking into account any traffic information provided over the external communication system and infrastructure information stored in the digital map and/or detected by the plurality of sensors;

g) transmitting the generated course, the vehicle condition data and the data acquired by the plurality of sensors to the vehicle control unit;

h) verifying in the vehicle control unit the functionality of individual vehicle modules and sensors and any intervention in the vehicle actuator system in order to bring the vehicle into a safe condition in the event of system defects relevant to safety;

i) generating a control vector for individual vehicle drive system actuators for implementing the generated course, taking into account data acquired by the object recognition device; and

j) transmitting the control vector to the control unit for controlling the vehicle actuator drive system to cause the associated control data to be transmitted from the control vector to the individual vehicle actuators.

31. A method in accordance with claim 30 including determining the traffic signal signs to be observed for each current route segment by use of the digital map and the video camera, and causing the control vector to be brought into agreement with the traffic regulations by using traffic regulation algorithms stored in the vehicle control device.

* * * * *